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PORTO RICO AGRICULTURAL EXPERIMENT STATION,
MAYAGUEZ, P. R.

Under the Supervision of the
UNITED STATES DEPARTMENT OF AGRICULTURE.

REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION.

1922.

Issued December 14, 1923.

WASHINGTON:
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[Under the supervision of the States Relations Service, United States Department of Agriculture.]

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PORTO RICO AGRICULTURAL EXPERIMENT STATION

MAYAGUEZ, P. R.

Under the supervision of the

UNITED STATES DEPARTMENT OF AGRICULTURE

Washington, D. C. ▼ December 14, 1923

REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION, 1922.

CONTENTS.

REPORT OF THE AGRONOMIST IN CHARGE.

By D. W. May.

The proper function of an experiment station is research, and instruction should not be expected of it. For many years after the establishment of the Porto Rico Experiment Station it was necessary to translate its work to a public not familiar with scientific agriculture. Fortunately this period is passed and the station can now turn more to the investigation of tropical agriculture, leaving to other agencies the popularization of its work.

FERTILIZERS.

The prosperity of the island depends primarily upon agricultural production, which in turn is contingent upon soil conditions. Nitrogen is the limiting factor in soil fertility and the largest element of expense in the annual fertilizer bill of the country. The imports of fertilizer, the greatest part of which was nitrogen, amounted in 1921 to 52,969 tons, valued at $3,165,611. The most inexpensive and practical method of supplying this element would seem to be in the growing of legumes. In the Tropics, where there is a 12-month growing season every year, legumes should be grown in rotation with cane and other crops, as they are well furnished with nitrogen-storing bacteria and yield large quantities of peas and beans for human consumption and forage for stock. Large numbers of valuable leguminous plants, including the velvet bean and *Tephrosia candida* for coffee plantations and pastures, and the soy bean and sword bean for forage and green manure, have been introduced by the station.

Many of the heavy soils, especially in the interior, require liming to neutralize the acidity and bring about better tilth. In various sections of the island there are many deposits of natural lime that is soft enough to be cut with a spade and spread over the fields. Planters should determine the lime requirement of their soil and then apply this element in the best form commensurate with the cost.

VEGETABLE GROWING.

With few exceptions, every vegetable that grows on the mainland can be grown in Porto Rico. Notwithstanding this fact, few vege-

tables ever reach market, due to the prevalence of insect and fungus pests and to the inertia of many farm hands who would rather hire their labor in an overcrowded market than produce crops for themselves. With a view to remedying this defect the station has, by the distribution of seeds and the dissemination of practical information relative to vegetable growing, sought to encourage the raising of vegetables at home.

Radishes, turnips, and carrots are easily grown in Porto Rico and are troubled by very few pests. Turnips grow quickly and the tops are available as greens. Successive plantings of this crop should be made, as the roots become tough and bitter. Beans, which are largely imported for use with rice, should be grown to supply local needs and for export as they were during the World War. Both the garden and sweet pea can be successfully grown when the soil is inoculated with nitrogen-fixing bacteria. Of the former, the tall growing sorts give the largest yields and over the longest periods. Inoculated soil should be obtained from the station for use in growing peas, and the crop should be grown in the winter. Lettuce ranks first among the salad vegetables and is now grown quite extensively. Of the many varieties tested by the station, Mignonette has given the best results, heading nicely and being crisp and tender. The seed of lettuce should be sown in boxes which are protected from ant invasion. Kale and Chinese mustard are among the easiest crops to grow. Swiss chard does well and gives a number of cuttings. Okra is the surest all-the-year-round crop, and does well during even the time of heaviest rains. The improved varieties are much better and more prolific than the native kinds. Peppers, onions, tomatoes, beets, eggplants, kohl-rabi, cabbages, and cucumbers should be grown in every garden. Only the improved seed of eggplants should be used, as the native varieties run to seed and are thin-fleshed.

PLANTING SEASONS.

The temperature of Porto Rico is always conducive to plant growth, yet the time of planting is modified by rainfall, and occasionally by periods during which certain insects are abundant. There are no such limits to time of planting in the Tropics as in the Temperate Zone, and the ground should always be covered with some crop. Thirty days is sufficiently long for the growing of a leguminous crop such as the cowpea if it is to be turned under for green manure or fed.

One of the causes of delay in seeding and planting in Porto Rico is the widespread belief in the supposed influence of the moon on plant growth, many native farmers believing that some phases of the moon are more favorable for planting certain crops than others. While those connected with the station do not hold to such belief, it was thought advisable to conduct a demonstration to show that other conditions being advantageous it was not necessary to wait on the phases of the moon. Seeds of radish, oats, and sunn hemp (*Crotalaria juncea*) were sown at six weeks' intervals throughout the year, advantage being taken of seeding in all the phases of the waxing and waning moon. Other lots were grown under conditions excluding moonlight, and in still others six different soils were seeded under like conditions. Many hundreds of the resulting plants were weighed and measured, but no striking or consistent differences were

found. Such slight variations as were noted were not sufficient to influence the general growth of the plants over the whole period.

LIVE STOCK.

Much progress was made during the year with live stock, especially with dairy cattle. Quite a number of purebred dairy animals were imported as a result of the successful introduction of other such animals at a number of places following the active campaign for the eradication of the cattle tick (*Margaropus annulatus*), and the numerous demonstrations by the station of the growing of improved, nutritious feeds.

Data pertaining to dairying in Porto Rico were submitted for publicat on during the year.[1]

REPORT OF THE CHEMIST AND ASSISTANT CHEMIST.

By L. G. WILLIS and J. O. CARRERO.

RICE INVESTIGATIONS.

A study of some of the critical factors governing rice production has led to results that are of value not only to rice growers, but also probably have a bearing on certain phases of the culture of other crops.

Former investigations made to determine the relation of fertilizers and soils to the apparent physiological reaction of the rice plant, showed that chlorosis of rice, due to lack of iron, is associated with the presence of an excess of calcium carbonate in the soil. Investigations conducted during the year indicate that this effect is further governed by the nature of the fertilizing materials used in growing the crop. In other words, fertilizer compounds which in themselves or by virtue of a nonassimilable basic residue tend to precipitate iron are usually associated with the development of chlorosis, while fertilizers having nonassimilable acidic residues are effective in preventing chlorosis on a moderately alkaline soil.

Although rice is not a crop of great economic importance in Porto Rico, it serves well for use in experimental culture, being like many other plants in its physiological reaction to chlorosis on calcareous soil. The results obtained with rice probably explain the observation made in many experimental and commercial plantings, that sodium nitrate is valueless, while ammonium sulphate is highly satisfactory as a fertilizer for pineapples, and suggests that chlorosis of corn and of cane, as well as the frenching of citrus trees, can probably be remedied in many instances by the use of ammonium sulphate in the fertilizer formula.

It was also observed in the experiments with rice that excessive applications of nitrogenous fertilizers to plants grown on a compact soil caused a sterility which appeared to be the so-called straighthead disease. The occurrence of this trouble was governed by the quantity of nitrogen supplied and by the management of the soil with respect to irrigation. Plants made normal growth with nominal quantities of nitrogen regardless of whether the soils were flooded

[1] Porto Rico Sta. Bul. 29, Dairying in Porto Rico, copies of which may be had by addressing the agronomist in charge of the station.

continuously or intermittently, and were less subject to sterility when grown on soils that were flooded intermittently.

Analytical work on samples of rice grown with the various soil treatments is nearly completed, and it is hoped that some differences in composition may be found to throw light on the physiological causes of the observed sterility. Early observations indicate that the sterile condition is associated with an excessive accumulation of nitrogen in the plant tissues, and it is possible that the results obtained with rice may explain similar conditions in other economic plants. No doubt this investigation could be developed to include a study of the factors governing the time of blossoming of citrus trees, with results of great financial value to Porto Rico.

WORK WITH AGRICULTURAL LIME.

The interest which is being aroused in the use of ground limestone as a corrective of acidity of certain soils that are devoted to miscellaneous crops made it advisable to start an investigation to determine the relative value of the most abundant types of limestone. This work will probably be continued and reported upon next year. Liming may be expected to yield profitable returns on all acid soils excepting very sandy soils and with most crops excepting pineapples.

MANAGEMENT OF CANE SOILS.

In a further study of the nitrogen economy of cane soils it was found that nitrogenous fertilizers do not greatly increase the yield of the first cane crop and leguminous green manures are apparently of no advantage. The early growth of the canes' first ratoon, however, showed the effect of not having received nitrogen. The growing of cowpeas between the cane rows as a green manure to supply nitrogen to the soil resulted in a noticeable improvement in the appearance of the cane as compared with that in the check plats, but no conclusions can be drawn relative to the efficiency of this method until the experiment has been carried on for some time.

ANALYTICAL WORK.

The analytical work in connection with the projects of the division has taken so much of the available time that there has been little opportunity to undertake any miscellaneous analyses. Samples of juice from seedling canes were analyzed and a number of samples of ground limestone were tested for purity.

REPORT OF THE HORTICULTURIST.

By T. B. McClelland.

LEGUMES.

With irrigation, garden and field beans may be planted in the early winter with a fair assurance of dry weather for maturing the crop. Late winter or early spring planting should be made if a large crop is wanted. Two plantings were made at the station during the year, one in autumn and the other in spring. A severe drought followed the spring planting and so retarded germination that many plants failed to emerge from the ground until five weeks

after planting. Notwithstanding the long delay in germination, a fine stand and a heavy crop were obtained. Practically the whole crop was ruined between June 5 and 10, however, by the fall of 8 inches of rain, which flooded most of the field for days. Among the selections saved were various white strains which were derived from a cross with black Venezuelan and have been carried through several generations. In the progeny of this cross blackness of the seed coat is dominant over whiteness, and glossiness over dullness. The progenitor, presumably F_1, was a glossy black bean found in a row of black Venezuelan. The F_2 generation consisted of 1 glossy white, 2 glossy black, and 1 dull black type. The white threw only white in the F_3 generation, 5 glossy and 1 dull. The dull black threw only dull, 6 of which were white and 15 black. The glossy black threw 2 glossy and 1 dull white, and 9 glossy and 5 dull black. The F_3 generation from the two F_2 blacks then consisted of 9 white and 29 black. The F_4 generation from the 9 white-seeded plants consisted of 239 white and 1 black, the latter presumably the result of further crossing. Of the 29 black-seeded plants, 1 was discarded, 11 threw black only, and 17 threw 469 black-seeded and 151 white-seeded plants, a very fair ratio of 3 to 1.

From the two F_2 glossy beans, 7 dull and 16 glossy types were derived. The dulls all bred true for dullness. Of the 16 glossy-seeded plants the classification of the progeny of one, 6 glossy and 4 dull, was doubtful because of immaturity. Of the 15 others, 3 produced only glossy-seeded plants while 12 produced 255 glossy-seeded and 90 dull-seeded plants in the F_4 generation. Among the dull-seeded plants varying degrees of dullness or lack of gloss occurred.

Cover crops have been limited to two genera, *Tephrosia candida* and *Crotalaria* spp. The effect of the length of day, and in consequence the season of planting, was very pronounced on *T. candida*, plantings of which were made every season. Of eight species of Crotalaria, which were planted for comparative purposes, *C. juncea* at 2½ months after seeding had made the best development.

ROOT CROPS.

Sweet potatoes.—Of 36 varieties tested, Key West again led in production, yielding a little over 132 pounds of roots, or more than 2½ pounds per linear foot of row. White Belmont ranked second, with a production of 108½ pounds, or approximately 2 pounds to the linear foot. The planting was made in better soil than was the case last year, and the yields were much higher. The most promising varieties have been distributed.

Yams.—The yam crop was planted in much poorer soil than the year preceding, and gave in consequence much smaller crops with a smaller difference in yield between the staked and unstaked vines. In eight of the nine varieties grown, the yield of staked vines exceeded that of unstaked, and in the other the difference was less than 1 per cent. For the whole planting the staked vines averaged a 41 per cent greater yield than the unstaked. A recent yam acquisition, S. P. I. No. 46801, led all varieties in yield, exceeding its nearest competitor by 20 per cent and all competitors grouped by 77 per cent.

Yautias and taros.—In a test with 8 varieties of yautias and 4 varieties of taros, a spacing of 18 by 36 inches was compared with one 36 by 36 inches. In each variety the wide spacing gave greater

yields per individual plant, and for each taro variety the yield from equal areas was greater with the wide spacing, but for 7 of the 8 yautia varieties the yield from the narrow spacing exceeded that from the wide spacing for equal areas planted. If the yautia varieties are considered as a unit, the yield from the narrow spacing would be 19 per cent greater than from the wide spacing.

MANGOES.

The mango orchard now contains more than 500 grafted trees and numerous seedlings. It is thought that in time the collection of trees in this orchard will be one of the most comprehensive in the Western Hemisphere. During the year 41 seedlings, springing from 15 seed of a polyembryonic variety, Cambodiana, were added to

FIG. 1.—Fernandez mango (S. P. I. No. 19117). Tree bore over 200 fruits.

those already in the field to test their variation. Of those which have fruited to date, approximately half have come true to the parent type, and the others have shown some variation, but in most cases not enough to lessen their market value greatly.

The crop was unusually heavy this season, but was partly destroyed by the melon fly. Eight Philippine seedlings (Pl. I, fig. 1) bore fruit, most of which was diseased or fly stung. Practically all of those tested contained a high percentage of acid, due probably to premature dropping and ripening.

The variety Mekongensis fruited this season for the second time. In appearance and manner of production the fruit resembles the Philippine variety, but lacks the disagreeable acidity of the latter and ripens better. Representative fruits weighed from 200 to 350 grams (7 to 12 ounces). In form the fruit is elliptical, except for a concave depression on the apical half of the ventral side. In color it

varies from greenish yellow to deep yellow, tinged occasionally with pink. The texture is good, but somewhat more fibrous than that of the variety Cambodiana, to which both Mekongensis and the Philippine mango are closely related.

Chempadan, a variety introduced from Ceylon, fruited for the first time in sufficient quantity for testing (Pl. I, fig. 2). In this variety sweetness and acidity are well proportioned, and the flavor is very pleasant. The general form of the Chempadan is sub-ovoid, and in cross-section, round. In color it is orange, dotted with numerous green and black lenticels, and shows some russeting and a

FIG. 2.—Jack fruit. Weight, 29½ pounds; seeds, 2¾ pounds.

faint gray bloom. Fiber is thickly set over the ventral margin of the seed, but it is not as objectionable as that found in the Porto Rican mango. Representative specimens weighed from 125 to 300 grams (4 to 10½ ounces). Nearly all the fruits were found to be injured by larvæ of the melon fly, the interior showing a corky development instead of the usual soft rot occurring in Cambodiana and a number of other fly-infested varieties.

Fernandez (fig. 1) and Itamaracá fruited well and continue to give promise as valuable varieties for this locality in regard to both quality and quantity of fruit.

AVOCADOS.

Of a large number of Guatemalan avocado trees which were received in 1919, several blossomed during the year and set fruit which later dropped. The trees are rather small as yet, but their early fruiting tendency is promising.

JACK FRUIT.

The jack fruit (*Artocarpus integrifolia*) bore some large fruit during the year. (Fig. 2.)

COCONUTS.

The coconut fertilizer work was considerably extended during the year, cooperative experiments being conducted in three different localities. In a plantation of 8-year old coconut palms where the average yield in 1921 was only 11 nuts per tree, a yield averaging 45 nuts per tree was made on a plat to which common salt (sodium chlorid) had been applied. This plat continues to outyield other plats which received various fertilizer combinations. Having shown such pronounced effects here, sodium chlorid is being tested on an extensive scale in another plantation and on a third in contrast to two forms of potash. Nearly 500 palms are included in the coconut fertilizer work and individual records are kept of each palm.

COFFEE.

The cooperative fertilizer test with coffee was continued during the year as outlined last year.[2] Indications are that nitrogen and potash are relatively more important than is phosphoric acid as a fertilizer for coffee on the soil tested. It might, however, be advisable to apply a complete fertilizer if mineral fertilizers are to be used. The form of nitrogen continues to show itself most important in a field test under way. The trunk diameter of trees which were fertilized with ammonium sulphate was 22 per cent greater than that of trees fertilized with sodium nitrate, while the crop of the past season was 72 per cent greater for the former than for the latter. It is thought that the fertilizer experiments with coffee have progressed sufficiently to permit of the publication of the results within the near future.

Among the imported coffees, Excelsa is very promising for planting in certain sections of the island where the leaf miner severely damages the Arabian coffee. In growth this variety is very vigorous and in yield it is promising, the second crop from a planting of 40 trees averaging more than 4 liters (3.8 quarts) of berries per tree. This is the best of the coffees of the Liberian group so far tested by the station.

VANILLA.

Experimental work under way with vanilla had to be abandoned due to a root disease, presumably *Fusarium* sp. One planter marketed over 200 pounds of cured beans from his first crop and estimates that there are still 1,000 pounds or more on the vines. It is hoped that the success attained on this plantation may serve as an inducement to others to grow vanilla, more especially where old coffee trees are to be replaced. This may be done by interplanting coffee with vanilla after the old shade has been removed. By the time the new shade, which also serves as a support for the vanilla, is established and the vanilla comes into bearing, the old coffee trees may be removed and younger trees set throughout the planting. In this way the coffee may be renewed in connection with vanilla plantings at little expense. The land may be used for a single planting of vanilla, or it may be occupied by vanilla through a number of years.

[2] Porto Rico Sta. Rpt. 1921, p. 12.

FIG. 1.—PHILIPPINE SEEDLING MANGO.

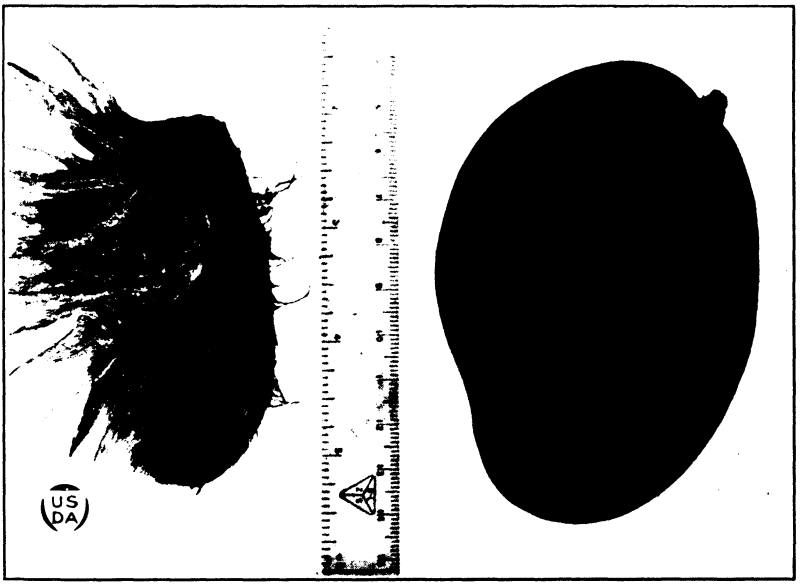

FIG. 2.—CHEMPADAN MANGO.

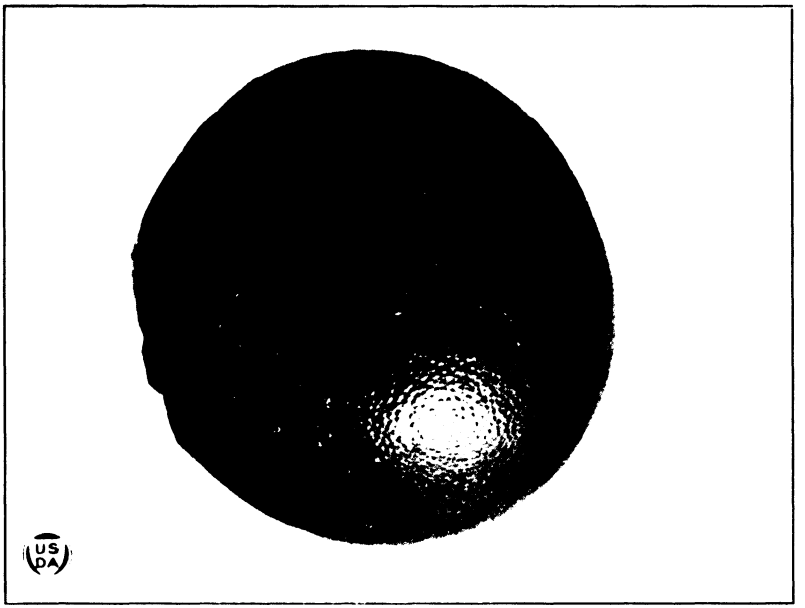

FIG. 1. GRAPEFRUIT SHOWING TRACE OF SCAB.

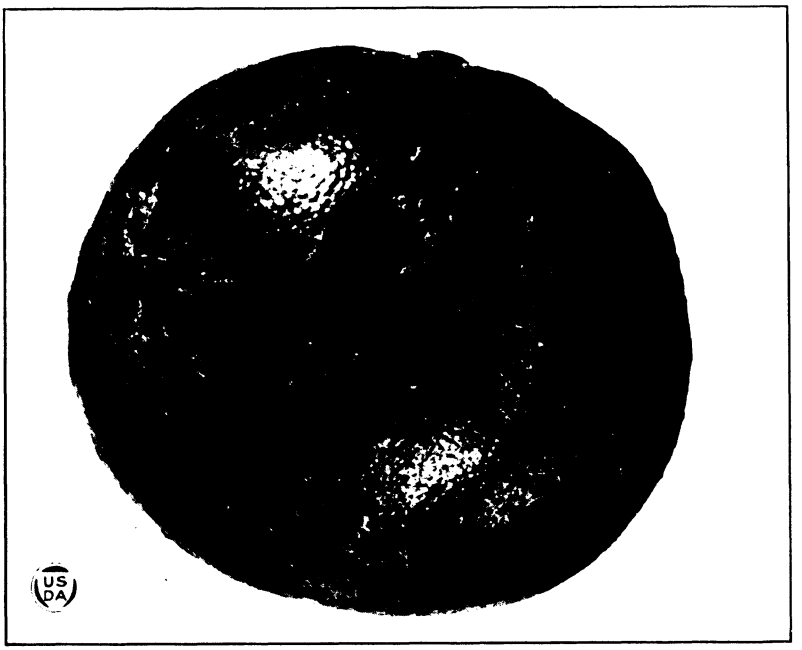

FIG. 2. GRAPEFRUIT SHOWING SOME SCABBY AREAS.

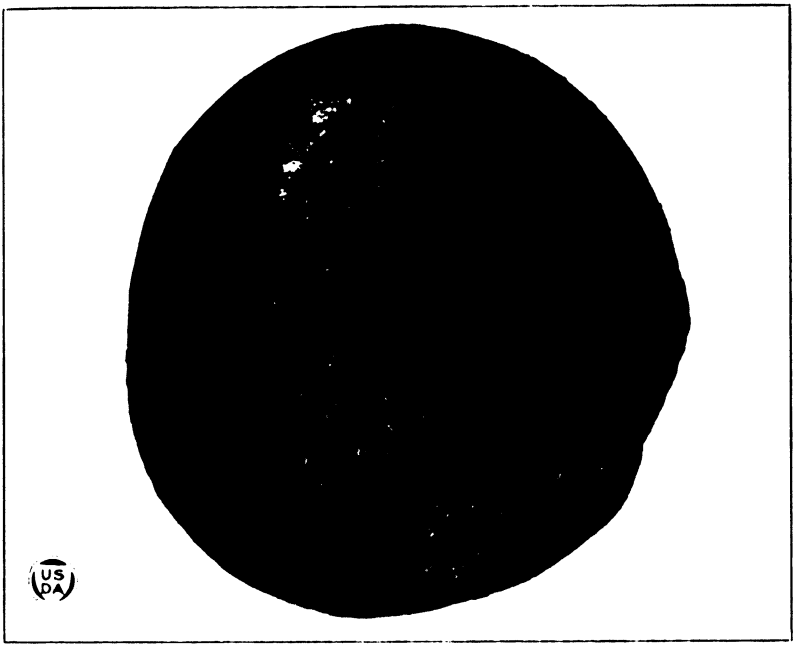

FIG. 1. GRAPEFRUIT. BADLY SCABBED, BUT NOT KNOTTED.

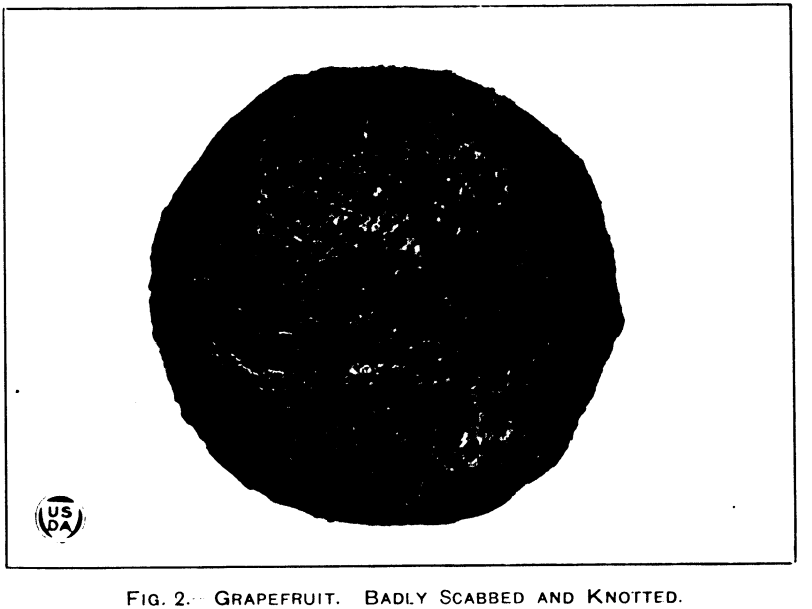

FIG. 2. GRAPEFRUIT. BADLY SCABBED AND KNOTTED.

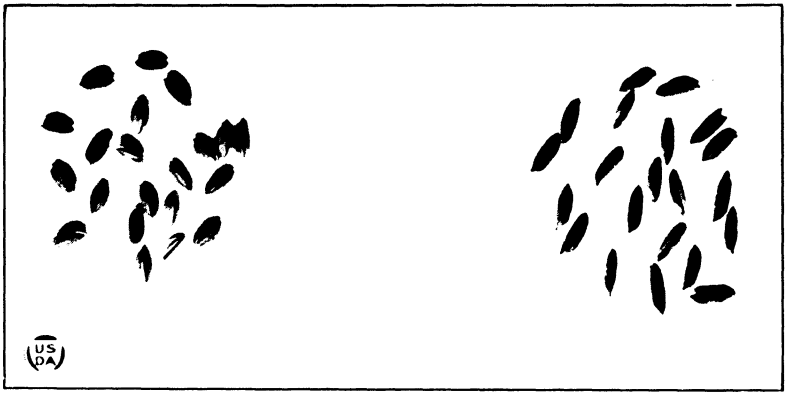

FIG. 1.—SOUND GRAIN. INFECTED GRAIN.

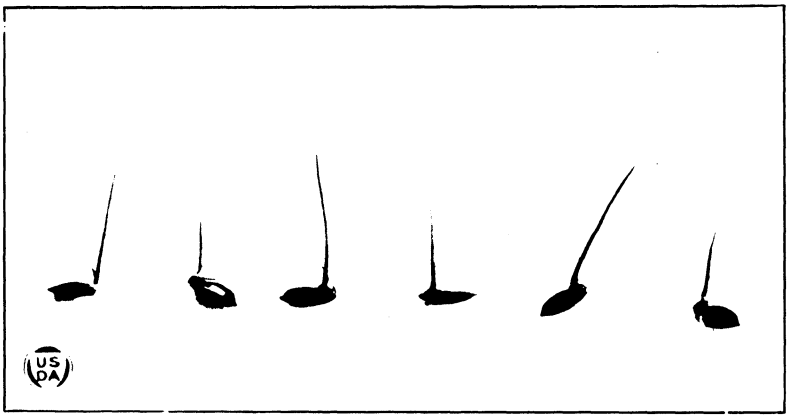

FIG. 2. GERMINATING INFECTED GRAIN. NOTE ABSENCE OF ROOTS.

FIG. 3.—CHARACTERISTIC SPOTTING OF LEAVES.

HELMINTHOSPORIUM DISEASE OF RICE.

REPORT OF THE PLANT BREEDER.

By THOMAS BREGGER.

GENERAL WORK.

During the year work was continued with corn, rice, eggplant, soy beans, cowpeas, and mungo beans.

Corn.—An ear-to-row cooperative experiment, having for its object the isolation of good strains of corn that are well adapted to the region and the demonstration of the value of seed selection over crib selection, was conducted in southwestern Porto Rico during the year. At the station Venezuelan corn from the delta of the Orinoco and native corn are under trial.

In the work of cross-breeding native corn was pollinated with Venezuelan and with sweet and field corn from the mainland. A few F_1 progenies of crosses with Venezuelan and mainland field corn varieties produced a small quantity of seed notwithstanding the insufficient irrigation. These second-generation seeds were planted with remnants of the first generation in the crop for 1922.

Rice.—Of the 178 different varieties or strains of rice which were turned over to the plant breeder in 1920, 118 came from the mainland and 60 were selected from native rice. With the cessation of the cooperation of the office of cereal investigations, Bureau of Plant Industry, United States Department of Agriculture, due to lack of funds for adequately carrying on the work, it became necessary to reduce the number of strains.

All the varieties were grown on the dark clay bottom lands of the station in 17-foot rows 3 feet apart. Every fifth row was planted to the Honduras variety and every tenth row to Wataribune rice as a check. Available records of four different plantings made during 1918–1920 show that the mean yields of Wataribune were too low to permit of the elimination of a greater number of strains, and the Honduras variety was used therefore instead. All strains exceeding the mean yield in two or more plantings were saved. Of these, 29 from the mainland and 11 from Porto Rico were selected for further trial.

Cowpeas, soy beans, and mungo beans.—While the yields of cowpeas for the two years are as yet scarcely comparable, it is interesting to note that New Era, a variety originated by the Hawaii Experiment Station, ranks first in yield for both 1921 and 1922. Conch and Brabham are consistently low for the two years. Seeds of many varieties of cowpeas have been introduced and distributed by the station within the past 20 years, but it has not been possible to follow up these distributions to determine what degree of success they have attained.

Of six varieties of soy beans, Biloxi and Otootan set a large number of pods, but were attacked by a disease which caused practically all of the seed to shrivel in the pods. Only sufficient seed for one plat was obtained of the Hahto variety and it germinated poorly. Individual selections of this variety are being made in the hope of obtaining a strain that is more adaptable to Porto Rico than the present type. Hahto has fairly large, flat green seeds suggestive of Lima beans and might be useful in the human dietary as a substitute for them, either dried or green. Individual selections of Mammoth and Haberlandt soy beans were also made and planted

in progeny rows, and mass selection of mungo beans and cowpeas were carried on.

Eggplant.—First generation plants of a cross between New York Improved and the native striped Pompona were grown during the winter and the yield per plant and measurement of individual fruits were recorded. The fruit of the hybrid is of intermediate size and shape and of purple color showing the underlying striped pattern of Pompona near the apex. Seeds from matured fruits of the first generation plants were saved with a view to making extended plantings of the F_2 plants.

Kidney beans.—Mass and individual selections of the red kidney bean, known on the local market as Americana, together with an anthracnose-resistant white bean, obtained from Cornell University

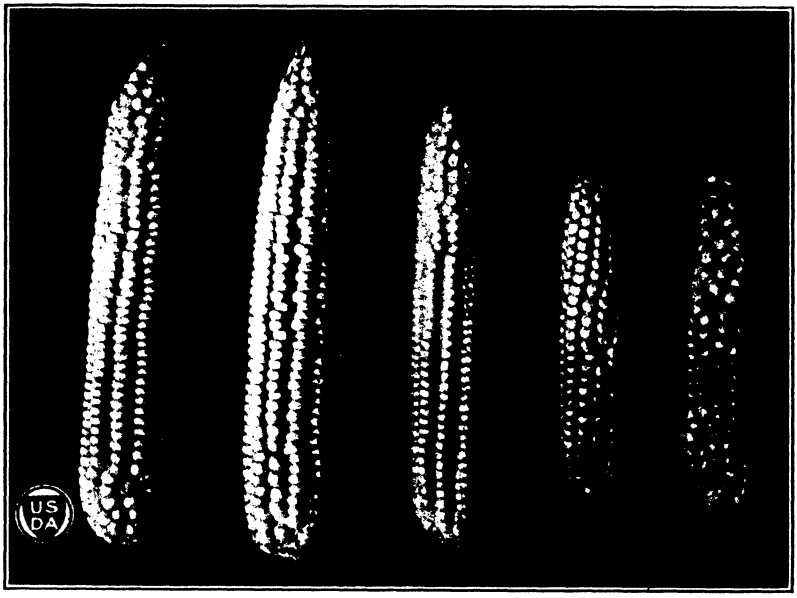

FIG. 3.—Native white corn. Space between rulers, 9 inches.

under the number F13, were planted to obtain natural crosses from which a strain of disease-resistant white bean, adapted to Porto Rico conditions, might be developed.

REPORT OF THE ASSISTANTS IN PLANT BREEDING AND HORTICULTURE.

By W. P. SNYDER and J. A. SALDAÑA.

SUGAR CANE.

Due to the unusually poor germination of arrows, the work in seedling cane production was a disappointment this year. About 15 protected crosses were attempted, not one of which produced a seedling. Bud selection with cane has been started to obtain (1) strains having a high sucrose content, (2) stools having a large

number of canes of greatest vigor, and (3) stools having the greatest weight.

FIELD CORN.

A small planting of field corn was made in January in order that studies on correlation between plant characters and yield might be continued. (Fig. 3.) Tests in which selection is based on plant and ear characters are being continued. Several abnormal characters have appeared in the self-pollinated strains as well as in some of the open-pollinated types.

SWEET CORN.

The station is still endeavoring to develop a variety of sweet corn that will be adaptable to island conditions. Some progress

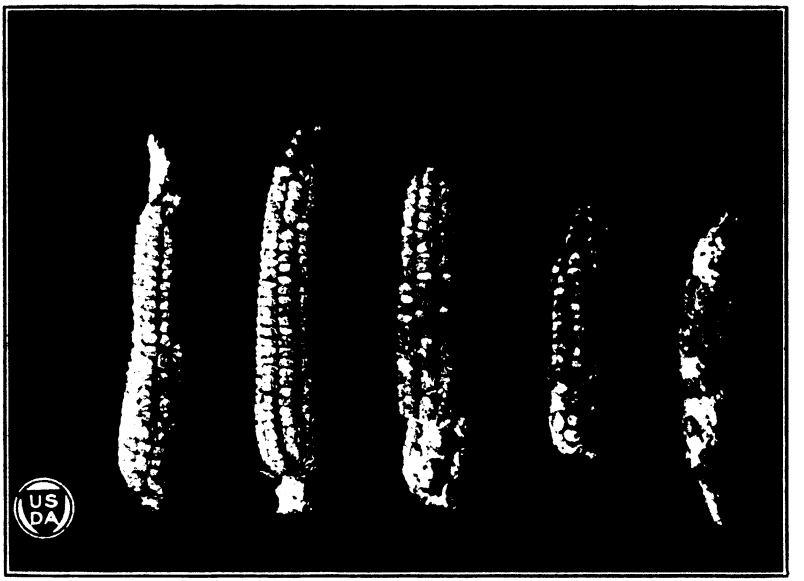

FIG. 4.—Native white×Henderson's sugar corn. Space between rulers, 9 inches.

has been noticed in the F_3 plants and in the F_4 ears of the hybrid under consideration. The parents of the hybrid (fig. 4) are Henderson's Sugar, a vigorous variety of sweet corn, and a white native variety of field corn. Henderson's Sugar failing to produce seed, the station is continuing its experiments with Henderson's Astor for comparison with the hybrid corn. Henderson's Sugar and Henderson's Astor are very much alike. In height, number of rows of kernels, and period of maturity, the hybrid occupies an intermediate position between the parents. Of 196 F_3 hybrids, 131 were vigorous, which feature is very much desired in the work of hybridization. Henderson's Astor produced no vigorous plants. The white native corn produced 90.7 per cent vigorous plants in 1922, and a slightly less number in other plantings. Yield, based on 69 plants, for three types, was in the order of merit for the 1922 planting, white native corn, 6.11 kilograms (13 pounds 7 ounces), hybrid, 2.6 kilograms (5 pounds 11 ounces), and Henderson's Astor, 125 grams (4 ounces).

WHEAT.

Varieties of Indian wheat were again tested on a small scale during the dry season. The kernels of many of the varieties were considerably shrunken and the yield of grain was very poor, the crop having been severely damaged by a fungus resembling a Helminthosporium. (Fig. 5.) Seed of the few plants making vigorous growth and producing a good crop of plump kernels was saved for

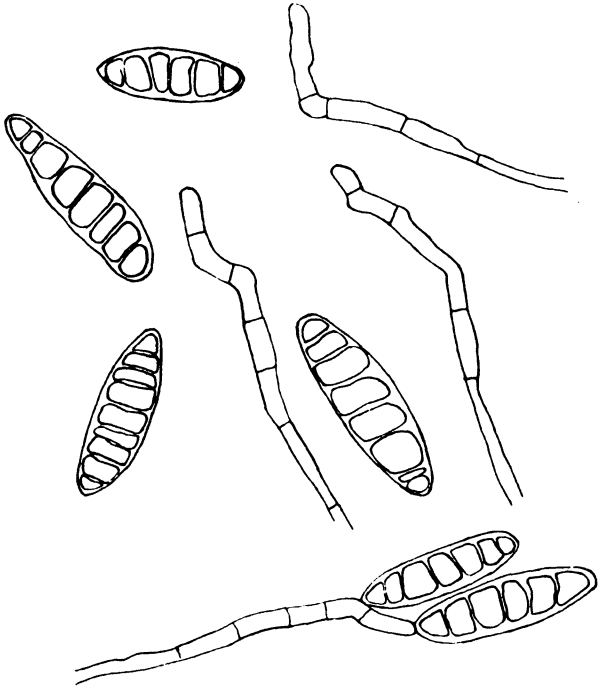

FIG. 5.—Conidiophore and spores of *Helminthosporium* sp. from wheat.

further trial. A crop is being grown under glass to multiply the more promising kinds and to permit of the observation of the effect of different soil treatments on yield of grain.

TOMATOES.

Tomato breeding work has for its object the selection of strains which are resistant to wilt, and improvement in the yield and type of fruit produced. The progenies of a number of individual wilt-resistant plants, grown in a plat producing a badly diseased crop of tomatoes last year, showed some apparently significant differences in their ability to resist wilt. The more promising selections obtained will be further tested.

The main planting, comprising about 1,200 plants, is located on land that had not been previously planted with tomatoes. This planting produced a very good crop which was only slightly damaged by disease.

The yield of Insular Station Tomato No. 443×Dierner cross was unexpectedly high in view of the reduction in yield of the F_2 generation due to wilt. All the second and third generation progenies of the past season were highly variable and promising selections were made from each of them. Prolific crossed with Stone and Globe with Prolific produced several fruits, each weighing a pound or more. One row of 48 plants did remarkably well, producing on the average 925 grams (2.04 pounds) of fruit to the plant, although they were not watered after their first day in the field and the rainfall during their growth amounted to only 10.77 inches.

MUSKMELONS.

Third and fourth generation plants of a native muskmelon crossed with Salmon Tint Pollock and with Hybrid Casaba produced fruits having both hard and soft rinds. None of the fruit came uniformly true to seed. Further selection will be made for yield, quality, uniformity of type, and for resistance to mildew.

BANANAS.

Plants which were selected for resistance to the Panama disease made slightly more vigorous growth than did unselected plants. Tobacco stems and wood ashes when applied to the soil had no apparent effect on plant growth or on the disease.

MISCELLANEOUS WORK.

Seedlings of the Duncan and Triumph grapefruit cross, 2½ years old, set out in the spring, made fine growth.

At 15 months after planting, biennial white sweet clover made light growth and produced practically no seed. It gave place to grass and weeds and did not seem to be adapted to island conditions. Seed of Hubam clover, raised from a few plants during the spring, will be given further trial.

REPORT OF THE ENTOMOLOGIST.

By W. V. Tower.

CITRUS SCAB.

Citrus scab is the worst pest with which the citrus fruit grower in Porto Rico has to contend. During the early years of the industry only young trees were attacked, but within recent years many old trees that once bore fine crops have produced fruit that is practically worthless for shipping.

A cooperative spraying experiment for citrus scab, started with one of the largest growers on the island, has given encouraging results during its first season. Some 3,000 trees setting blooms in December, January, and February were given four sprayings with a 3–4–50 Bordeaux oil emulsion carrying one-half per cent of oil. Usually the early winter bloom is not heavy, and when it comes during a cold rainy period, such as this did, the fruit is likely to be scabby. The first blooms appearing December 15, being few in number, were not sprayed until December 29. The second spraying was applied January 27, the third February 13, and the fourth,

March 9. No definite spraying program could be adhered to owing to the very unsettled weather and the small amount of fruit set from the first blooms. Fruit coming on after the final application of Bordeaux oil emulsion had been made was sprayed with lime and sulphur to kill the rust mites which were appearing. These trees produced 94.4 per cent clean fruit, 5.2 per cent showing a trace of scab, and 0.4 per cent which was spotted with scabby areas.

Trees in a check plat where the groves were the most severely infected and on which the early morning sun did not shine, gave 10 per cent clean fruit, 44.7 per cent showing a trace of scab (Pl. II, fig. 1), 27.5 per cent showing some scabby areas (Pl. II, fig. 2), 17.5 per cent which was badly scabbed but not knotted (Pl. III, fig. 1), and 0.3 per cent which was knotted and literally covered with scab (Pl. III, fig. 2). Sprayed trees in the same grove produced 90.6 per cent clean fruit, 9.3 per cent showing a trace of scab, and 0.1 per cent showing some scab areas.

Groves in the same vicinity showed a very high scab infection. One unsprayed grove produced 3.5 per cent clean fruit, 17.3 per cent showing a trace of scab, 24.4 per cent showing some scabby areas, 50.3 per cent which was badly scabbed but not knotted, and 4.5 per cent which was knotted and literally covered with scab.

Another grove on the same property was divided into three plats, the first two of which were sprayed four and two times, respectively, and the third of which was left unsprayed. The yield of clean fruit per plat was 91.2, 83.9, and 24.5 per cent, respectively.

A grove of 900 trees, sprayed January 13 and April 12 with Bordeaux oil emulsion (3–4–50, to which was added ½ per cent of oil emulsion) produced 97.3 per cent clean fruit. These trees set a very heavy bloom on May 11 and the grove was sprayed with lime and sulphur.

Another grove of 800 trees, which also blossomed late, was sprayed on April 5 and May 8 with Bordeaux oil emulsion. The blossoms appeared April 29 and were heavy May 9. The trees produced 93.8 per cent clean fruit, 6 per cent showing a trace of scab, and 0.2 per cent which was slightly spotted with scabby areas.

Recent tests with the oil emulsion were made at the station with grapefruit trees bearing 6-months-old fruit. The solution applied had the following strengths, 1, 1½, 2, 2½, and 3 per cent of oil emulsion, and where applied neither the leaves or fruit burned nor did the leaves drop.

In all tests made with Bordeaux and oil (3–4–50–0.5), only a few of the young shoots burned. No small fruit or open blossoms were injured by this strength of spray. A few unopened blossoms burned and dropped, but no serious loss of leaves occurred.

The results obtained with Bordeaux oil emulsion are most encouraging, but the spray should not be used unless the grower is prepared to fight the scale, which is sure to follow. The campaign should be well planned and the spray thoroughly applied. Only the best spraying material should be used and a constant watch should be maintained for scale and rust mites.

For any extended spraying program with Bordeaux oil emulsion, sufficient stocks of concentrated solutions of lime, copper sulphate, and oil emulsion should be made separately and stored in advance so that everything will be ready when the rush of spraying starts.

REPORT OF THE SPECIALIST IN FARM MANAGEMENT.

By H. C. HENRICKSEN.

THE CITRUS FRUIT INDUSTRY.

At the beginning of the shipping season 1921–22 freight service between Porto Rico and New York was inaugurated by a steamship company having three vessels, two of which had refrigeration and ventilation and were capable of carrying upward of 40,000 boxes of fruit each, and the third of which had ventilation but no refrigeration. At the beginning of the shipping season 1922–23 another steamship company installed refrigeration and ventilation in a large vessel plying between Porto Rico and New York with the result that the entire fruit crop can now be shipped, and with less loss than formerly, provided the recommendations made by the experiment station are followed.

Facilities were provided by the first-mentioned company to enable the writer to observe conditions in the various holds of its vessels. Two trips were made from Porto Rico to New York with fruit which was literally followed from the field to the consumer. This work terminated the investigations undertaken to ascertain some of the factors affecting the price of citrus fruit, and the results were prepared for publication during the year.

Laboratory tests were undertaken during the latter part of the year for the purpose of helping local growers overcome some of the difficulties encountered in artificially coloring fruit by means of gases. It was found that practically all gases may produce spotting of the rind when they strike the fruit with some force, and that a chemically active gas, such as chlorin or sulphur dioxid, when allowed to settle on the fruit, may produce spots on the rind. It was also found that vapor of ether, chloroform, and ethylene impart an odor or taste to the pulp, and that all or any mixture of gases or vapor in which there is little or no oxygen cause the fruit to develop an unpleasant odor or taste after 24 to 48 hours. Loosening of the stems may occur, resulting in Diplodia decay, when the fruit is exposed for considerable time to any gas except oxygen. "Popping of the stems," however, is not caused by the gas, but rather by the mixture of an insufficient amount of oxygen with the gas. It may be prevented by forcing fresh air into the coloring room in such quantity as to keep the oxygen supply at about 15 per cent of the atmosphere, and by keeping the air in motion. The results of the investigation suggest the even distribution of the gases by means of a fan placed outside a coloring room having inlet and outlet tubes. This will permit of the room being kept closed and the air rotated instead of renewed. The supply of gas should be ample and contain a higher percentage of acrid substances than is found in the exhaust products of gas engines. For this purpose the heavier oil products, such as tar or pitch, should be given a thorough trial. The mixture of gas and air should contain enough oxygen to provide for the unhindered respiration of the fruit and also enough gases of the kind that attacks coloring matter to produce the desired color change.

PINEAPPLES.

The pineapple is one of the most profitable fruit crops in Porto Rico when growing conditions are favorable. Due to an apparent

soil exhaustion independent of the plant food supply and to a deterioration of the plant relative to the production of fruit and slips, this is not always the case. Slips which formerly had free entrance from Cuba are now admitted subject to a duty of 25 per cent ad valorem. This and the increasing scarcity of slips will likely curtail the pineapple industry in Porto Rico unless some method is found for the local production of sufficient vigorous and prolific slips to plant new fields. Much research work covering several years is involved in the study of these problems, but when it is finished the results should furnish answers to many problems in addition to those mentioned.

MISCELLANEOUS WORK AT THE SAN JUAN OFFICE.

Agricultural Extension Notes dealing with original research work and subjects of a popular nature were again published during the year.

In January the writer gave a series of lectures at the insular experiment station at Rio Piedras to all the field agents of the insular department of agriculture and labor and to the agricultural teachers of the department of education. The lectures dealt with tropical horticulture and farm management adapted to local conditions.

Films and slides, obtained from the United States Department of Agriculture, were used to illustrate other lectures of an educational nature.

REPORT OF THE ACTING PLANT PATHOLOGIST.

By C. M. Tucker.[3]

A BROWN SPOT DISEASE OF RICE (Helminthosporium sp.)

The rice harvested from 37 test plats during the past season was observed to be discolored, in many instances, by small brown spots on the glumes (Pl. IV, fig. 1).

Early evidence of infection on the seedlings appeared at the collar, where a brown ring was apparent just below the first leaf sheath. The ring of infected tissue usually girdled the seedling. This ring is of light color and gives the infected area the appearance of being in the first stage of decay. The infection was usually confined to the outer layers of the collar tissues and did not cause the immediate death of the seedling. The young leaves were spotted with small oval, brown spots extending through the tissue to both sides of the leaf and often elongate in the direction of the long axis of the leaf, which was killed in many instances. Brown lesions sometimes appeared on the first leaf sheath, extending through the tissues but not penetrating the young inclosed leaf; the latter, however, usually developed spots of infection after emerging from the sheath. The roots of infected seedlings turned brown and died as the fungus progressed along them. In some instances, seedlings were killed by root infection alone, exhibiting no evidence of infection on the leafy portion (Pl. IV, fig. 2). In test tube cultures all the seedlings having infected roots died, while a few of those showing leaf in-

[3] Affiliated with the Porto Rico College of Agriculture and employed temporarily by the station.

fection only, recovered. In each instance the death of the seedling was followed by the appearance on the roots and collar of a gray mycelium which grew and bore spores abundantly. As the plants matured the leaves became spotted with oval or elongated, dark brown, while in the center of each spot there was a gray area of dead tissue containing the mycelium (Pl. IV, fig. 3). The spots on the grain appeared as very small circular or oval, dark brown discolorations, shading toward the edge of the spot to a lighter brown. A portion of the grain had spotted endosperms which were so deep as to fail to be removed during milling and polishing.

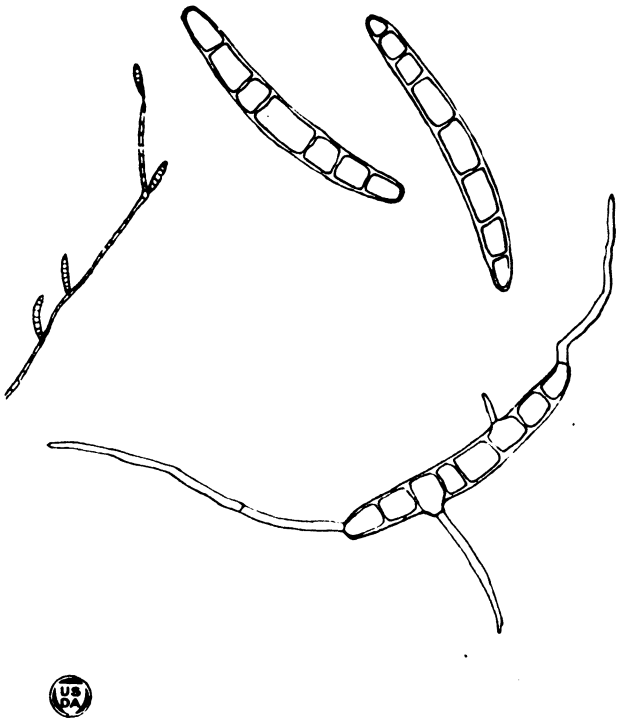

FIG. 6.—Conidiophore, spores, and germinating spore of *Helminthosporium* sp. from rice.

The plants were classified as to infection on coleoptile, root, or on both, to determine where the first symptoms appeared and to get the infection and germination percentage of each seedling. Many of the seeds germinated poorly and were covered with a mycelium characteristic of Helminthosporium. Seeds which failed to germinate supported a thick growth of the fungus. More than half of the infected seedlings showed symptoms of infection on both root and coleoptile, which seems a natural result of infection by a seed-borne organism. Of the 207 infected seedlings, 176 died before reaching a height of 6 inches.

Evidently the fungus does not penetrate the leaves in every case of coleoptile infection. The soil is a better medium for the growth of the seedlings than is the nutrient solution and increases their power of resistance.

Examination of the mycelium from diseased seed, seedlings, roots, etc., proved it to be of the same fungus (*Helminthosporium* sp.). Pure cultures were obtained by making direct transfers from these colonies to potato agar slopes. Investigations failed to disclose evidence of a sexual or perfect stage of the species. It is thought that secondary infections occur on the leaves and heads from primary seedling infections and that diseased seed will produce a diseased crop. Disease-free seeds planted in the field at considerable distance from other rice produced seedlings showing no symptoms of the disease, but when the plants had reached a height of 6 to 10 inches the characteristic spots began to appear on the leaves. This particular type of infection seemed much less virulent than the seedling infection and could not have had its source in the soil, since rice had not been planted there in recent years. The infecting spores may have been carried by the wind from distant fields or from other hosts of the fungus. Further investigation will determine whether any of the species are identical with the species of Helminthosporium attacking cereals and common grasses (figs. 5 and 6). Soil infection is a possibility if not a probability, but results to date indicate that seed infection is the primary source of disease.

Preliminary results at the station indicate that chemical disinfectants are of little value in controlling seedling blight of rice. The most practical means of control would seem to be in the selection of clean seed. Infection may readily be distinguished by the brown spotting on the seed coat. Examination of a sample of seed will easily determine the approximate percentage of infection.

A DISEASE AFFECTING GRAPEFRUIT TREES.

Numbers of grapefruit trees are dying in the Manati section from a disease which seems to have had its origin in a single tree and thence spread slowly but constantly in all directions. Affected trees assume a chlorotic appearance, the leaves turning yellow and the young growth showing more or less frenching. So far as it is known, affected trees have never been restored to normal condition. Ferric sulphate sprays, copper sulphate solutions as a soil drench, and heavy applications of various fertilizers have been of no avail. Slightly decayed specimens of the roots of dying trees were found to support a large variety of saprophytic fungi. A large number of plates, made by covering small bits of surface-sterilized root with agar, showed the constant presence of a *Fusarium* sp. This organism makes very sparse growth on agar media and on grapefruit leaf agar, but grows rapidly and produces an abundance of white mycelium on sterilized grapefruit roots. The freshly cut root of seedlings, when placed in contact with fungus-covered pieces of root, showed no evidence of disease.

The affected trees are growing in a red clay soil which is neutral in reaction. It may be that this soil contains in an unavailable form some essential plant food for these trees. The slow spread of the disease may be explained by some such peculiar slow change going on in the soil and subsoil. It is doubtful if an organism is responsible for the disease. As yet no recommendation can be made for its control.

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PORTO RICO AGRICULTURAL EXPERIMENT STATION
MAYAGUEZ, P. R.

Under the supervision of the
UNITED STATES DEPARTMENT OF AGRICULTURE

REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION

1923

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PORTO RICO AGRICULTURAL EXPERIMENT STATION

[Under the supervision of the Office of Experiment Stations, United States Department of Agriculture]

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PORTO RICO AGRICULTURAL EXPERIMENT STATION
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REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION, 1923

CONTENTS

REPORT OF THE AGRONOMIST IN CHARGE

By D. W. MAY

During the fiscal year the work of the station was conducted along the same general lines as in the previous year. Definite progress was made in all activities, and results on the whole were satisfactory.

The mosaic disease of sugar cane, which in past years considerably decreased the yield of sugar, has been brought under control to a considerable degree by growing immune or apparently immune cane varieties, and by roguing the fields of infected stools. In order to overcome losses due to various factors, the station is growing new varieties from seed in the tassel, studying the fertilizer requirements of cane soil, practicing a rational system of rotation by planting velvet beans and Crotalaria in the whole field and cowpeas and beans in the young cane, and installing up-to-date machinery to keep down the growing cost of labor.

There has been small increase in the area planted with coffee, notwithstanding the fact that some of the varieties introduced by the station are being successfully grown. The main hope of the coffee industry lies along the line of diversification.

Since the American occupation, fruit growing has made the greatest gains of any of the industries. An indication of the great increase in all lines of production is perhaps best reflected in the external trade of the island which has, in less than 25 years, grown from $17,000,000 to over $200,000,000 annually.

RURAL CREDITS

The Federal farm loan act (approved July 17, 1916), enabling farmers to borrow money on farm-mortgage security at a rate of interest not exceeding 6 per cent, has been extended to cover Porto Rico. Loans of the character authorized by this act are assisting many of the farmers to clear off old debts on which they have been paying 12 per cent. The latter rate, while legal on the island, is disastrous for the farming industry, more especially since notarial fees, the cost of registration, and the annual tax on the mortgaged property must be paid in connection with it.

REFORESTATION

In order to provide the forests for water conservation and other purposes, the station has planted approximately 10,000 mahogany trees (*Swietenia macrophylla*) on the 200-acre tract on the mountain above Mayaguez. The trees are making good growth, varying with the type and quality of the soil. Other trees doing well include camphor, mango, and avocado. Leguminous nurse trees, such as the cojoba (*Copaifera hymenæifolia*) and dwarf bucare (*Erythrina corallodendron*), are being planted in the more sterile places. Dwarf bucare grows readily from cuttings, affords shade for coffee, and serves as a windbreak for citrus and as a support for vanilla. (Pl. I, fig. 1.) Velvet beans should be planted as a cover crop after the bucare is started. Other legumes adapted to forest planting while the trees are young include peas, beans, Crotalaria, peanuts, and sweet clover.

ANIMAL INDUSTRY

Cattle.—As a result of the introduction of purebred bulls, the dairy cattle of the island are beginning to show noticeable improvement in capacity and in general conformation. Dairy practices, too, are more in accordance with sanitary requirements than was formerly the case. A new concrete dairy building was erected during the year (Pl. I, fig. 2.) Cattle, when they can be afforded, lend themselves to the permanent development of the country.

During the year, four purebred Guernsey heifers and one bull were added to the station herd, which formerly consisted of native cows crossed with purebred bulls. The cattle tick (*Margaropus annulatus*) has been brought under control sufficiently to permit of the importation of purebred cattle by the general stock farmers, while the successful growing of elephant and Guatemala grasses, and other crops suitable for grazing purposes, would seem to assure an abundance of nutritious feed at all times for the animals. (Pl. II, fig. 1.)

Pigs.—Pigs thrive in Porto Rico, but are employed largely as scavengers. The number of grain and root crops suitable for pig feeds should be increased if pig raising is to become an industry.

Poultry.—Although poultry can be produced at a profit in Porto Rico, both refrigerated fowls and eggs continue to be imported at high prices. The few fowls which are kept on the farms subsist altogether upon the "pickings" about the yards and stables. Poultry

should occupy an important place in the diet of the million and a quarter people on the island and be a means of increasing the revenue of the small farmer.

VEGETABLES

Results of experiments made to determine the adaptability of northern varieties of vegetables to island conditions indicate that, with good seed and proper cultural methods, turnips, tomatoes, kohlrabi, peppers, okra, carrots, and peas can be profitably grown here. (Pl. II, fig. 2.) Pea seed, however, should be planted in inoculated soil, or should be inoculated with the proper bacteria, which can be obtained from the station for the purpose. The crop makes small growth when the soil is not inoculated.

FLOWERS

Mainland flowers doing well at the station include nasturtiums, zinnias, snapdragons, violets, balsam, petunias, phlox, and sweet peas. Only the summer flowering sorts of sweet peas should be planted, as the others do not produce blossoms. When the soil is planted with sweet peas for the first time it should be inoculated with nitrogen-fixing bacteria.

REPORT OF THE ASSISTANT CHEMIST

By J. O. Carrero

MANAGEMENT OF CANE SOILS

The study of nitrogen economy in cane soils was continued, the first ratoon crop being harvested early in the year. This ratoon sprung from plant cane that had been damaged by a storm in 1921 and some of the stools died as a result. The experiment is being carried out on a fairly rich clay soil which, as the result of having received fair amounts of fertilizer as well as lime in other experiments, failed to give striking results in the first trial. Since nitrogen is apparently the fertilizing element which is the controlling factor in cane production, the plats were given liberal applications of phosphoric acid and potash, the nitrogen being supplied in the form of nitrates, and through the agency of a green-manuring crop. Certain sections were limed, and others were left unlimed to serve as checks. When no nitrogen was used, the unlimed plats yielded one and one-half times as much as did the limed plats, the gains holding regardless of whether green manure was used. When nitrogen was applied, the unlimed plats were still ahead of the limed plats in yield, but the difference between them was small, especially when sodium nitrate was used as the source of nitrogen. In the first ratoon crop, the unlimed plats were in the lead, the yield being more pronounced than was the case in the plant cane crop. Small gains were made by plats of plant cane, and large gains by plats of ratoon cane, following treatment with green manure.

With the addition of nitrogen, the unlimed plats of plant cane gave a slightly higher yield than did the limed plats, regardless of

whether green manure, sodium nitrate, or ammonium sulphate was used. In the case of ratoon cane, the same differences, though far greater than for plant cane, were observed in favor of the unlimed plats. A comparison of the plats showed that nitrogen produced a greater gain on the limed than on the unlimed plats.

Apparently lime considerably depressed the effect of the phosphoric acid used on the limed plats, since the increase in yield of the nitrogen plats over those receiving no nitrogen was not sufficiently large to overcome the gain made by plats to which soluble phosphates and nitrogen were applied in combination. The experiment will be continued for some time to determine the full effect of the different forms of the nitrogenous fertilizers applied, as well as the residues, on nitrogen utilization. Data will be kept regarding the fertilizing elements used by the crop, the amount returned to the soil in the trash, the ash burned in the form of bagasse, and the quantity in the cane juice.

STUDY OF SULFOFICATION OF PORTO RICAN SOILS

The various sulfofication experiments being carried on are arousing considerable interest. Especially is this true of the experiments in which raw phosphate is being converted into soluble form by sulfofying bacteria. The numerous caves of the island contain tons of deposits of bat guano, which is not in an immediately available form owing to its tricalcium phosphate, and in many cases, calcium carbonate, nature. Plans for sulfofication experiments with bat guano are under way to learn whether it can be converted into a readily soluble product.

ANALYTICAL WORK

The greater part of the year was devoted to analytical work on samples of various crops which were grown in connection with rice that became affected with the so-called straighthead disease when treated with excessive applications of nitrogenous fertilizer. Approximately 200 seedling canes, together with cane from the fertilized plats, were analyzed. Soil, fertilizer, and other samples submitted by farmers, were analyzed in every case where the results were thought to be of general agricultural interest.

REPORT OF THE HORTICULTURIST

By T. B. McClelland

LEGUMES

Considerable breeding work was done in connection with the regular varietal experiments with beans. Comparative plantings of 66 rows, each 100 feet long, were made during the latter part of February, which is about as late as beans should be planted if the crop is to be harvested before the heavy rains begin. In 16 of the rows the plantings were from selections that had been studied individually.

FIG. 1.—DWARF BUCARE PLANTED FOR SHADE AND WINDBREAK FOR YOUNG CITRUS TREES

FIG. 2.—NEW DAIRY BUILDING OF CONCRETE AND TILE

FIG. 1.—NAPIER OR ELEPHANT GRASS ON HEAVY CLAY SOIL

FIG. 2.—CHAMPION OF ENGLAND PEAS AT STATION

Drought followed seeding and so retarded germination that the plantings were in varying stages of development in early April, ranging from sprouting seed to plants in blossom. The tropical varieties again demonstrated their superiority over varieties which were imported from the temperate regions, showing that of the number tested they were best able to withstand unfavorable weather conditions. The black Venezuelan yielded in 18 rows on the average 6 pounds 2 ounces of dry beans. This yield was surpassed by 16 rows, comprising 9 of the black Venezuelan, 5 of white strains which were derived from a cross with the black Venezuelan, and 2 of buff beans that were introduced from Brazil. The maximum yield for the black Venezuelan was 9 pounds 10 ounces, and for the white strains 7 pounds 14 ounces. The two rows of Porto Rican red averaged 3 pounds 1 ounce. Since the local market objects to the black color in beans, it is hardly likely that the black Venezuelan, although the heaviest yielder of all varieties so far tested, will ever become established locally. Many white selections from crosses with the black Venezuelan are being tested, and it is thought that there are some valuable strains among them.

A variety having mottled seed coat and fleshy pods was received from Manchuria (China) during the year. So far it is proving one of the most vigorous and productive of the sorts introduced from temperate regions.

Cover crops were again limited to two genera, *Crotalaria* spp. and *Tephrosia candida*. Of the species of Crotalaria, *C. juncea* and *C. striata* (large-leafed form), and a variety known at the station as No. .04277, attained a height of 125, 90, and 70 inches, respectively, at four months from seed. The small-leafed form of *C. striata* was little more than half as high as the large-leafed form, and *C. usaramœnsis*, *C. incana*, and *C. sericea* were intermediate in height. *C. sagittalis* and *C. retusa* each reached a height of about 25 inches. Due to their small growth, these species are not as desirable for cover crops as are some of the other sorts. When cut 145 days after planting, sections of *C. juncea* and *C. striata* gave a fresh weight per acre of 18.1 and a little less than 16.8 tons, respectively. (Pl. III, fig. 1.) After the plants were thoroughly sun dried, the weights were reduced to 6.1 and 4.2 tons, respectively. Of the several species grown, *C. juncea* gave the most satisfaction as a cover crop, making vigorous and rapid growth, and smothering out encroaching weeds. *C. juncea*, *C. sericea*, and *C. usaramœnsis* are all well worth growing as ornamentals.

A study of the photoperiodism of *T. candida* showed that a range of 2.2 hours in local day length is sufficient to determine the blossoming season and modify decidedly the growth of the plant. The investigation will be reported upon later.

MISCELLANEOUS INTRODUCTIONS

Hibiscus.—Although many varieties of ornamental hibiscus grow in Porto Rico, their number is small compared with the kinds found growing in some other parts of the Tropics. Considerable interest is being shown in the growing of this plant as a hedge and for ornamental purposes. Cuttings of some of the beautiful varieties have been introduced from Hawaii and elsewhere and crossed with the widely distributed native sorts. At this writing (June 30, 1923),

approximately 250 seedlings have been produced as the result of the crosses.

Paraguay tea.—Among other plant introductions which are doing well is Paraguay tea (*Ilex paraguayensis*), which should prove of economic value to Porto Rico (Pl. III, fig. 2).

ROOT CROPS

Sweet potatoes.—In a comparative planting of thirty-eight 50-foot rows, Madeira led in production, yielding 183 pounds 7 ounces of roots. Key West ranked second with a yield of 174 pounds 13 ounces. This production was at the rate of 3½ pounds or more per linear foot of row, or 15 to 16 tons per acre. Their nearest competitor, a local variety, yielded at the rate of less than 2½ pounds, and only 5 other varieties gave a yield of 2 pounds or more per linear foot. Key West is deemed a desirable variety for extensive plantings in this locality since it held first rank for two seasons and was a close second for the third season. The variety has been extensively distributed throughout the island. Its roots are of good marketable size, medium to large, and more or less oval in shape, while the flesh of the baked potato is yellow, moist, soft, and sweet, and of good quality. Due to their low yields through three years, the varieties Pumpkin, Dooley, Big Stem Jersey, Red Jersey, Early Red Carolina, and Red Brazil (No. 5978), and Improved Big Stem (No. 21403) have been discarded.

Yams.—Plantings were made of 13 varieties of yams, 10 of which were tested to ascertain the effect on them of staking. The staked vines yielded twice as much as the unstaked vines grown on areas of equal size. For three seasons the value of supporting the vines has been clearly demonstrated, staking affecting not only the weight of the total production of each plant but also the size of its tubers.

Yautias and taros.—Varieties of yautia and taro were again planted at distances of 18 by 36 inches and 36 by 36 inches. The close spacing gave a yield 26.7 per cent greater than the wide spacing for the yautias, and 12.5 per cent for the taros, for equal areas planted, the taro yields reversing the order of results obtained last year. Although a spacing 18 by 36 inches may give a slightly greater area yield than does a spacing 36 by 36 inches, it requires twice as much seed, and does not permit of the free use of an animal-drawn cultivator, as is true in the latter case.

COCONUTS

In the fertilizer work with 9-year-old coconut palms, the check plat produced at the rate of only 36 nuts per tree, while the plat to which common salt (sodium chlorid) was applied led with a production of about 69 nuts per tree. The plats which were given ammonium sulphate in combination with either acid phosphate or potash, or with both, produced on the average 60 to 67 nuts per tree, which was considerably in excess of the yield made by the plat receiving a large part of fertilizer in the form of manure and tobacco stems, or by the plat receiving no nitrogen in the fertilizer. Increasing each semiannual application from 5 to 10 pounds failed to cause any increase in yield.

In the two plantations where salt and potash are being tested, the experiments have not progressed sufficiently to permit of the drawing of conclusions.

COFFEE

Experiments conducted during the last 8 years with coffee trees, grown on 40 small plats of heavy clay soil, demonstrate in a striking manner the need of potash as a fertilizer. (Pl. IV, fig. 1.) Of the 10 plats making the best yields in 1922, 2 had received a complete fertilizer; 3, nitrogen and potash; 2, acid phosphate and potash; 2, potash alone; and 1, no fertilizer (check). Nine of these 10 plats had received potash; 5, nitrogen; and 4, acid phosphate. Twenty plats receiving potash singly or in combination made 2¾ times as great a yield as did the same number of plats differing in treatment only in that they received no potash.

The difference in efficiency of the nitrogen carriers, ammonium sulphate and sodium nitrate, has been pronounced on coffee growing in clay soil. In a pot experiment 30 containers, each having a capacity of 5 gallons, were filled with clay soil and then planted with 2 seedlings each. The experiment was divided into 3 groups, of which 2 were fertilized and 1 was left to serve as a check. The former 2 groups received ammonium sulphate (8 grams), or sodium nitrate (10 grams), carrying equivalent amounts of nitrogen, at intervals of 6 months. At a little less than 18 months from setting, the trees receiving ammonium sulphate surpassed those receiving sodium nitrate by 26 per cent in height, 103 per cent in number of leaves, 112 per cent in weight of leaves, and 93 per cent in weight of trunk and branches. The trees receiving sodium nitrate differed from the trees receiving no fertilizer by less than 1 per cent in height and by 5 to 16 per cent in the other particulars. In a new test being started on sand, loam, and also on clay, sodium nitrate will be applied monthly as well as semiannually.

For many years the station has been introducing and testing different varieties of coffee. During the year, data were submitted for publication on the characteristics of these varieties, and their performance at the station.[1]

REPORT OF THE PLANT BREEDER

By THOMAS BREGGER

GENERAL WORK

During the year breeding work was continued with corn, rice, eggplant, and several leguminous crops, including beans, cowpeas, soy beans, mungo beans, and velvet beans.

Corn.—In an ear-to-row experiment, having for its purpose the isolation of better yielding strains of corn adapted to the region, native varieties of corn were grown at the station and cooperatively at Isabela. At Mayaguez, the mean yield for 106 duplicated rows of ears was 2,546 pounds per acre, with a minimum and maximum yield of 1,832 and 3,291 pounds, respectively, per acre. At Isabela, the mean yield from 89 rows of ears was 2,139 pounds per acre, with a

[1] Porto Rico Sta. Bul. 30, Coffee varieties in Porto Rico, copies of which may be had by addressing the agronomist in charge.

minimum and maximum yield of 968 and 3,668 pounds, respectively, per acre. Remnants of the 5 lowest and 5 highest yielding selections grown at Mayaguez and at Isabela were planted in isolated multiplication plats at Mayaguez during the spring of 1923. Progeny of the best selections of the 1921 rows of ears were grown for further increase and selection.

Second generation plants, the result of crossing northern sweet corn and dent corn with native varieties, were grown, and selections were made from these for further test and observation.

Rice.—Of the 178 different strains of rice which were turned over to the plant breeder in 1920, 42 were continued in replicated 18-foot plats of 3 rows each, and in 18-foot rows 3 feet apart on both upland and lowland soils. Observations were made of the dates of heading and maturing of the rice, and likewise of the prevalence of *Helminthosporium oryzæ*. Seed of a variety of rice from Honduras was distributed in limited quantities to planters requesting it, and several plantings were made to enable the station to distribute large quantities in 1923.

Eggplant.—Second generation plants of a cross between the native striped Pompona and New York Improved were grown in the garden during the winter. Practically all the hybrids were purple fruited and of good size. A few bore fruits resembling the native parent in color or skin, but like the New York Improved in size. Seed from several plants was saved for further selection with a view to establishing the type. A few plants were grown on the Mesa farm, and cions from two of the best purple-fruited sorts were grafted on the wild eggplant (*Solanum torvum*) in the hope of establishing a small commercial planting. When in full bearing, over half the plants were destroyed by a wilt, probably due to *Bacterium solanacearum*.

Beans, soy beans, cowpeas, and velvet beans.—Mass and individual selections of these crops were grown for another generation. Data relative to the yield of 10 varieties of cowpeas and 6 varieties of soy beans were obtained from replicated 40-foot plats of five rows each. New Era again took first rank of the cowpeas, and Virginia made the highest yield of the soy beans. Otootan and Biloxi, both late-maturing varieties of soy beans, made excellent growth and set a large number of pods, but were again attacked by a disease causing practically all of the seed to shrivel in the pods.

Selections of black, gray, and mottled velvet beans, derived from previous introductions, were planted on the poorer upland soils of the station. Inoculated seed of the varieties Osceola, 100-Day Speckled, and Bunch gave very disappointing results when planted on the Mesa, due to the high percentage of iron in the sterile soils.

REPORTS OF THE ASSISTANTS IN PLANT BREEDING AND HORTICULTURE

By W. P. Snyder and J. A. Saldaña

SUGAR CANE

Of the newly introduced varieties of cane, E. K. 28 and an unknown sort from Java seem to be worthy of further trial (Pl. IV, fig. 2). The variety E. K. 28, although showing some symptoms of

FIG. 1.—CROTALARIA JUNCEA, LEFT, AND C. STRIATA, RIGHT, GROWN AS COVER CROPS

FIG. 2.—PARAGUAY TEA, RECENTLY INTRODUCED INTO PORTO RICO

FIG. 1.—COFFEE TREES ON RIGHT RECEIVED 11 OUNCES OF SULPHATE OF AMMONIA PER TREE. TREES ON LEFT, SAME PLUS 9 OUNCES OF SULPHATE OF POTASH

FIG. 2.—UNKNOWN VARIETY OF SUGAR CANE FROM JAVA, IMMUNE TO CHLOROSIS

mosaic disease, continues to make vigorous growth. The unknown variety from Java belongs to the North Indian family of canes, and is very similar to the Uba or Kavangire. It can be distinguished from the Uba, however, by its swollen internodes and by the ease with which the leaves separate from the stalk. This variety is extremely vigorous and apparently is immune to the mosaic disease. Two varieties, received from Mauritius and Barbados, have not been sufficiently tested to ascertain their merit. The variety P. O. J. 213 seems to be rather easily affected by mosaic disease.

The following table gives the Brix hydrometer reading, sucrose content, and purity of juice of first ratoon and plant cane harvests:

Composition of the juice of first ratoon and plant cane[1]

Variety	Brix reading	Sucrose	Purity
First ratoons, 11 months old:	*Degrees*	*Per cent*	*Per cent*
Uba	16.86	13.67	81.10
P. O. J. 36	19.04	17.18	90.25
P. O. J. 234	19.71	17.88	90.67
G. C. 1480	18.37	16.13	87.80
G. C. 1486	19.32	17.20	88.86
St. Croix 12/4	19.31	17.24	89.26
Plant cane, 16 months old:			
P. R. 260	17.26	13.90	80.50
P. R. 292	17.43	14.73	84.50
G. C. 701	18.09	16.11	89.05
G. C. 1313	16.20	12.91	79.70
G. C. 1480	13.83	9.52	68.80
D. 117	17.33	14.88	85.90
B. 4596	14.28	10.44	73.10
B. H. 10/12	18.58	16.08	86.50
P. O. J. 213	17.63	15.46	87.70

[1] The samples ground ranged from 30 to 90 pounds.

Bud selection experiments with the P. O. J. 36 and Uba varieties gave negative results, and were therefore discontinued.

All cane seedlings which were grown in 1919 and 1921 and became affected with mosaic disease were destroyed. Attempts were made during the winter to produce seedlings by fertilizing the arrows of Uba cane with pollen from cane varieties P. R. 292 and M. P. R. 7. No seedlings were obtained, however, the ripe arrows of cane varieties P. R. 292 and M. P. R. 7 germinated so poorly as to be considered poor pollenizing sorts. In an effort to induce seed to germinate, the station planted a number of arrows in both sterilized and unsterilized soil and in seed boxes which were covered with glass. The plantings were watered with a weak solution of sodium nitrate, which in some instances was applied through bamboo tubes reaching to the bottom of the boxes. Beneficial results were obtained in cases where the boxes were covered with glass or where sterilized soil was used. Few seed germinated, however, in cases where subsurface irrigation was practiced. This method has the disadvantage of not permitting the uniform distribution of moisture through the boxes. The following list gives the average germination per box of the different varieties: P. R. 359, 298.1; D. 109, 281.7; P. R. 492, 37; B. 1809, 33.6. The varieties B. 6450, St. Croix 12/4, M. P. R. 7, D. 216, G. C. 1480, and P. R. 358 produced less than 10 per box. The varieties P. O. J. 36, P. O. J. 105, P. O. J. 213, Uba, P. R. 292, and B. 4596 gave no germination whatever. Fully 35,177 seedlings, including those of D. 109 and P. R. 359, were produced from a total of

350 boxes of seed. Of these seedlings, only 8,237 were set in the field, the others either dying or being discarded at the time of transplanting.

WHEAT

During the summer and fall pot experiments were carried on under glass to observe the behavior of wheat under different cultural and fertilizer treatments. The results, while not very conclusive, would seem to indicate that the yield is decreased by (1) planting too deep (2 inches); (2) planting in a trench which is filled in with soil as the plants grow; (3) giving the crop an insufficient supply of water, that is, about 0.6 of an inch per week; (4) withholding water from the crop after about 10 days after heading; and (5) failing to use fertilizers. Clipping the young plants gave conflicting results. Mulching with cane trash increased the yield, regardless of whether the plants were watered at the rate of 0.6 or 0.9 of an inch per week. Adding lime to the fertilizer, withholding potash from it, or varying the amount of nitrogen in it had no appreciable effect on yield.

Each of the varieties was planted in one to fifteen 4-foot rows and tried out under irrigation during the winter. Owing to the poor stand made the yield per row could not be calculated. The Indian wheats, C. I. Nos. 4558 and 4695, however, clearly outyielded all others, as they had done in each of the three preceding tests.

TOMATOES

Approximately 1,700 tomato plants were grown during the winter, including commercial varieties, mixed stock of unknown origin, and second, third, and fourth generation hybrids. The best yielding varietal selections were obtained from Sutton's Best-of-All, Lares Native, Norton, and New Century Wilt Resistant, which produced on the average 3.1, 2.24, 2.2, and 2.04 pounds, respectively, of fruit per plant. Norton, obtained under the name Stark's Blight Resister, and Burpee's Self-Pruning were tested for the first time. Stark's Blight Resister not only proved of value in its apparently marked resistance to wilt, but it also made a fair yield of good, solid tomatoes, some of which, however, had a tendency to crack. Burpee's Self-Pruning made a poor showing, giving the lowest yield of all the varieties grown.

Crosses were made between imported and native varieties in the hope of producing strains having greater vigor than the ordinary commercial varieties but maintaining the improved type of the latter. Although some of the commercial varieties have been known to yield as much as the native sorts, the progeny averaged considerably higher in yield than either parent. As a result of these crosses the yield of fruit has increased, but there has been no marked improvement over the best varietal selections in wilt resistance. In some instances the bitter flavor of the native parents has not been entirely eliminated and in others the fruits are not as smooth and uniform as is true of the commercial varieties.

Crosses were also made between the different imported varieties in the hope of obtaining a vigorous growing, heavy yielding, wilt-resistant strain which will produce fruit of good size and shape. The progeny obtained by crossing Globe with Mack's Prolific, both of which were discarded because of their low yields, have outyielded each parent.

In order that observation might be made of their wilt-resistant ability, promising selections were grown in a plat on which several successive crops of tomatoes had succumbed to wilt. Of these, Stark's Blight Resister showed the greatest degree of resistance, only 21 per cent of the plants dying within 162 days after planting. Selection No. 105, from Insular Station Tomato No. 443, was next, three plants out of 13, or 24 per cent, dying. Two of the selections from unknown parentage showed a fair amount of resistance, while No. 5–8, the progeny of Greater Baltimore and Native, was poor, and Sutton's Best-of-All very poor.

In September a trial of tomatoes was made at an elevation of 1,000 feet on the Mesa, near Mayaguez, the varieties Norton Wilt Resistant, Globe crossed with Prolific, and Burpee's Self-Pruning being planted. A considerable number of the fruits rotted, due to infrequent harvesting, and others were bruised and mashed during the haul by oxcart to Mayaguez. Notwithstanding these losses, the total yield of sound fruit, weighed at Mayaguez, was 1,674 pounds, which was at the rate of 10.7 tons per acre.

MUSKMELONS

The fifth generation plants resulting from a cross of a large native muskmelon with Salmon Tint Pollock and with Hybrid Casaba were grown during the winter. Due to noncontrol of the pollination through several generations, the different selections are still highly variable. Apparently little progress can be made in this respect until self-pollinated or close-pollinated seed is obtained.

SWEET CLOVER

Seed of Hubam clover, produced from plants grown at the station last year (1922), was sown on a small plat November 21. Later, 22 plants were transplanted in order that they might make a uniform stand. They made thrifty growth, reaching a height of about 6 feet, and produced a good crop of seed (1 pound 8 ounces), which was ready for harvesting May 12. The weight of the dry plants was 6 pounds 10 ounces.

SWEET CORN

Sweet corn breeding work, having for its object the development of a vigorous hybrid that will be adaptable to island conditions, was continued. The F_3 hybrids are more vigorous than the parents, and the F_4 ears of the hybrid under test show some improvement over the sweet corn introduced from the States.

REPORT OF THE ENTOMOLOGIST

By W. V. Tower

FUMIGATION EXPERIMENTS FOR THE CONTROL OF THE CIGARETTE BEETLE

The entomologist spent three months of the year in fumigating the warehouses and factories of the largest tobacco company in Porto Rico. Cigars and stored tobacco had become so generally infested

with the cigarette beetle (*Lasioderma serricorne*) that all buildings in which tobacco is handled in the process of manufacture, including all workrooms, had to be fumigated. Fully 4,750,000 cubic feet of space was fumigated. The warehouses were treated with 40 ounces of sodium cyanid per 1,000 cubic feet for 48 hours.

The entomologist also assisted a continental concern in demonstrating the use of liquid hydrocyanic acid as a fumigant in two warehouses, both piped with one-fourth inch black iron pipes. In one of the warehouses, which is 200 by 60 by 16 feet, the following plan was carried out: Pipes were run lengthwise through the center of the building to the outer walls where they were connected with solution tanks. The pipe lines were raised about 9 feet from the floor and carried 6 or 7 spray nozzles that were directed toward the floor. When all was ready, the liquid was pumped under pressure into the pipes and evenly distributed through the building, being expelled through the spray nozzles in a mist which immediately turned to gas.

The operator must be as careful when handling tanks of liquid hydrocyanic acid as when fumigating by the pot or barrel method. Liquid hydrocyanic acid is twice as powerful as solid cyanid or cyanid solution, and will certainly cause trouble if the pipes leak. Considerable time is required to charge the machine in the liquid hydrocyanic-acid method, but reckoning, weighing, handling of the material, and having to dispose of the residue, are dispensed with. The operator should not only wear gloves to protect his hands from painful burns, but he should also be provided with a gas mask in case of emergency. Commercial concerns should permit fumigation to be done only by a thoroughly efficient operator, such as a chemist, entomologist, or other person who is acquainted with the nature of poisons.

The method used for fumigating baled tobacco can also be used for Porto Rican cigars which have been packed for shipment. The gas penetrates the cigars and kills any insects present, regardless of their stage of development. Owing to the relatively humid air of Porto Rico, fresh cigars should be aired for three or four weeks, and others longer, after being fumigated.

Fumigation was started about the middle of February, and although the work was not completed until about the first of June, losses due to returned cigars began to decrease in April. The April statement from the New York receiving house to the San Juan office showed a saving of 40 per cent over previous losses occurring in May and June (75 per cent each). At the receiving house it was thought that a great proportion of the remaining 25 per cent loss was on old stock which had not been fumigated. It is also possible that the cigars became reinfested in the New York storage terminal.

The New York house was not alone in reporting a decrease in loss. Selecting and inspecting room managers formerly had to discard as many as 10,000 wormy cigars in some months, and to employ a large force to examine every box, cigar by cigar, in which a wormy cigar was found. By fumigating their houses, tobacco companies have been enabled to cut expenses appreciably. Very few wormy cigars are now found in the factories.

CITRUS SCAB, SCALE, AND INSECTS

The winter and spring months had a marked influence on the presence of scab. The long rainy season was followed by the worst period of drought Porto Rico has experienced in years. Some districts suffered more than others. In many instances, the rain interfered with spraying programs, and the required number of applications could not be made. One of the largest local growers, who obtained excellent results in the cooperative scab control experiment conducted in 1922, sprayed his whole plantation of 4,000 trees. He could not carry out the program as planned, however, because of adverse weather conditions, and his present crop is not as clean as was that of 1922.

During the dry period many growers could not clean up the scale that always follows sprayings with Bordeaux-oil emulsion. Both the purple scale and the rufous scale severely attacked the fruit in some of the plantations where the trees had been sprayed with the emulsion.

Rust mites and red spiders are very troublesome in citrus groves after the trees have been sprayed with Bordeaux-oil emulsion. When lime-sulphur is used following the emulsion, the leaves and fruit become covered with a reddish-brown precipitate, which gradually disappears, or is washed off as the fruit passes through the brushes in the packing houses.

COTTON INSECTS

In December, 1922, hundreds of acres of cotton in the Cabo Rojo district were destroyed by cutworms and a species of caterpillar (*Alabama argillacea*). At the time the entomologist visited the district, caterpillars were crawling over everything, all trees and bushes being covered with them. This section is very dry during the greater part of the year. Large salt works occur along the coast, but there is a very fertile sandy loam back of the beaches. Fine crops of cotton and corn are produced when there is a little rain.

If spraying is undertaken for control, it should be done as early in the morning as possible before the heavy breeze begins to blow, which is about 10 o'clock. Dusting as a method of control does not seem practicable, because of the absence of dew and the presence of heavy winds. Good results were obtained from the use of poison bait.

VEGETABLE AND FLOWER INSECTS

From time to time the entomologist is called upon to prepare spraying solutions for various members of the station staff who are working with vegetables and flowers. Sweet corn, which has not as yet been successfully grown in Porto Rico, was repeatedly sprayed with nicotine sulphate (5 cubic centimeters of the sulphate to 1 ounce of soap) to kill the lice, leaf hoppers, caterpillars, and other insects feeding upon it. The treatment effectively held the pests in check, but had no repellent qualities. In some instances, as high as 15 cubic centimeters of nicotine sulphate was sprayed without burning the plants. Striped cucumber beetles (*Diabrotica innuba* and *D. bivit-*

tata), which attacked casaba melons, cucumbers, and watermelons during the winter months, were brought under control by the use of a spray made with Bordeaux (2–3–50) and arsenate of lead (1½ pounds). The striped cucumber beetle was present in great numbers in the soy bean experimental plats during the summer months, and nematodes caused serious losses in truck gardens, attacking celery, beets, carrots, peppers, tomatoes, eggplants, dahlias, dracænas, and melons. Plant lice were found on dahlias and zinnias.

STORAGE OF GRAPEFRUIT

For the last three years the entomologist has been trying to determine the best method of storing grapefruit for home use. The fruit has been found to keep for a short time, say two or three months, in dry sand, sawdust, or coconut fiber, and for a longer period in moist sea sand or clear river sand, moist sawdust, or moist coconut fiber. The fruit should be thoroughly cleansed of scale before storing, otherwise it will break down as the scale increases. Two weeks after the fruit has been placed in storage it should be looked over carefully and the decayed specimens removed. In many instances, few decayed fruits were found in lots of grapefruit that had been stored three and four months. The longest period of storage was 14 months, but losses began to occur after the fifth month. The varieties showed little difference in keeping qualities when the matured fruit was stored. Of the lots tried, Pernambuco had the best keeping qualities, with Marsh Seedless ranking second and Duncan third.

In order that the best results may be obtained, the fruit should be picked when it has reached its prime. This is true especially concerning the Marsh Seedless, the seeds of which will sprout soon after the mature fruit is placed in storage. The Duncan variety, when fully mature, seems to hold up better than does the Marsh Seedless, the flesh retaining its normal color and fine eating qualities, and seeds not sprouting so quickly. Fine-skinned fruits were found to remain in good condition longer than those with coarse skin. Sprouting seeds are often found in fruit which remains too long on the tree, say from 14 to 16 months, and the seed of mature fruit sometimes sprouts after a rain follows a long drought.

Clean, moist sand or sawdust is probably the best material in which to store grapefruit for home use. Dry sand may be used, but fruit shrinks when stored in it a short time. Storing grapefruit for short periods in dark, moist chambers gave satisfactory results, the fruit not shrinking for two or three months. Shrinking occurred when the fruit was stored for six months in the open in moist chambers, but not when it was stored for the same length of time in moist coconut fiber in moist chambers. Heavy losses, due to sun and rain, occurred in about 500 grapefruits which were stored in coconut fiber in the open, and at the end of three weeks a lot of 30 cases of loose oranges showed a decay of 66 per cent when stored in coconut fiber in the open.

Cockroaches, which considerably damage stored fruit, may be held in check by the use of roach pastes. Grapefruit when stored should be well protected from rats.

MISCELLANEOUS

The giant toad (*Bufo agua*), which was introduced into Porto Rico several years ago, is rapidly increasing in number in this part of the island, and will doubtless assist in lessening certain of the insect pests. Horned lizards and horned toads, which were released in the dry lands of southwestern Porto Rico, have not as yet been seen in this section.

REPORT OF THE PLANT PATHOLOGIST

By C. M. Tucker

Since his appointment in June, 1923, the plant pathologist has spent the major part of his time in planning and preparing for various lines of investigation which are to be undertaken. The entire collection in the herbarium was card-indexed, and some additions were made to it.

A BROWN SPOT DISEASE OF RICE (Helminthosporium sp.)

Experiments are being continued for the control of seedling blight of rice, due to a fungus (*Helminthosporium* sp.), both hot water and chemical seed treatments being used. A study is being made of the possibility of soil infection, insects as disseminating agents, and of varietal resistance.

A ROOT DISEASE OF VANILLA

Vanilla, recently introduced into Porto Rico, gives promise of becoming a paying crop in certain sections well adapted to it. The original vanilla planting at the station was destroyed by a root disease which is proving a menace to the industry elsewhere on the island. Numerous examinations of the organism from infected roots, obtained from three different plantings, showed it to be the same fungus (*Fusarium* sp.). Pure cultures were isolated and used to inoculate potted plants that are growing in sterilized coconut fiber. Both pots and plants are covered with cheesecloth. Another series of inoculation experiments was made with plants which are growing in large glass tubes of sterilized fiber.

The old vanillery was selected as an ideal place in which to test the fungicides for use in controlling the disease in an infected soil. The supporting trees (*Erythrina corallodendron*) were thoroughly cleansed by scraping all adhering vanilla roots from them and by washing the trunks and main branches with Bordeaux mixture (5–5–50). Disinfectants were applied to the soil and organic matter was placed about the base of the trees. The disinfectants included carbolineum, copper sulphate, chlorid of lime, formaldehyde, sulphuric acid, paradichlorbenzol, lime, and Bordeaux mixture. Cuttings were then planted, and some of them were given applications of lime or Bordeaux mixture at certain intervals.

Laboratory work will be undertaken as soon as the causal organism is definitely established, to determine its resistance to various chemicals and to test its pathogenicity to other plants.

BANANA WILT

Since 1916 a plat of Chamaluco bananas, the soil of which is thoroughly infected with the banana wilt, or Panama disease, organism (*Fusarium cubense*), has been under observation for the selection of resistant plants and the production of an immune or resistant strain. So far the results have not been encouraging. The plants were recently cultivated and each was given an application of 2 pounds of a 6–8–10 fertilizer.

A Fusarium which seems identical with that mentioned above was obtained from a diseased pseudostem of plantain which was recently received from Fajardo, in the eastern part of the island. Porto Rican banana growers are of the opinion that most varieties of bananas are susceptible to wilt in varying degrees. Plans are being made to determine the pathogenicity of the fungus to some of the most commonly grown varieties.

SCAB-RESISTANT GRAPEFRUIT

An experiment, undertaken for the production of a scab-resistant variety, was turned over to the plant pathologist by the assistant plant breeder. The seedlings resulting from a cross between Duncan, a commercially valuable variety, and Triumph, a relatively scab-resistant variety, are now about three years old. When carefully examined in October for evidence of scab infection on the young leaves and stems, 48 trees were found to be heavily infected, 89 slightly infected, and 187 free from infection.

Climatic conditions at the station differ from those obtaining in the principal citrus sections of the island. At Mayaguez the rainy season is coincident with the season of highest temperatures. Along the northern coast in the citrus region the rainfall is rather heavy in the early spring, while the temperature is comparatively low, creating ideal conditions for scab infection.

Individual records are being kept for each seedling, and those showing continued resistance to scab will be budded on rough lemon stock in some location that is favorable to infection for further trial of resistant strains.

REPORT OF THE SPECIALIST IN FARM MANAGEMENT

By H. C. Henricksen

The principal lines of investigation conducted by this division during the year included studies of some of the critical factors governing pineapple production, the shipping and keeping qualities of pineapples, artificial coloring of citrus fruit, changes taking place in precooled citrus and pineapple fruit, and the marketing of onions.

PINEAPPLES

Pineapple-production investigations have not advanced sufficiently to permit of the publication of a report at this time, but the work is progressing favorably and the results are very promising. Plants

were grown in water and sand cultures to which different chemicals were added, and potted plants were grown in soils that were taken from pineapple fields where the crop showed certain characteristics. The pot culture experiments yielded more valuable data than did those conducted in the field from which the soils were taken.

Results of a study made to determine the rate at which the pineapple matures when it is kept at various temperatures, and likewise of the maturity changes occurring after refrigeration, showed that a temperature ranging from 50° to 60° F. for one week will partly arrest maturity changes, and that even plant-ripened fruit may be kept at this temperature for the same length of time with little change, unless, of course, it is infected with fungi. Green fruit will not perceptibly change color when it is kept at the above-mentioned temperature. A temperature ranging from 35° to 40° F. will arrest maturity changes considerably, regardless of whether the fruit is ripe or green. When very green fruit is kept in storage for 6 days only, it will mature upon removal from refrigeration. The fruit will not show normal change in either color or composition, however, if it is kept for a period longer than 6 days in a room where the temperature ranges from 35° to 40° F. In other words, pineapples which are precooled for a short period at a temperature as low as 35° F. will ripen normally upon being removed from refrigeration; and fruit that has fully ripened can be stored for some time at a temperature of about 40° F.

In connection with a study of the effect of temperature on shrinkage, it was found that fruit shrunk very little when well packed and kept for 6 to 10 days in a room where the temperature ranged from 35° to 40° F. Of the various protective measures against shrinkage, that of covering the fruit with paraffin gave the most satisfaction under certain conditions. The paraffin was kept several degrees above the melting point. The fruit was dipped up to the crown, and then held over the boiler to allow the excess paraffin to drip off. Green and bronze-colored fruit should not be covered with paraffin since it hinders subsequent color changes. Large, fancy, plant-ripened fruit, such as is suitable for window display, may be paraffined, as it will show to better advantage and keep in good condition longer than will unprotected fruit.

CITRUS FRUITS

Inasmuch as the price of citrus fruit is largely determined by its appearance, the color is naturally of great importance. The problem of artificially coloring fruit was attacked at the beginning of the shipping season. Further investigation along this line will be made as soon as time permits.

Shippers and carriers have manifested considerable interest this year in the question of precooling fruits. In order to ascertain the temperature which will arrest stem-end rot of oranges and grapefruit, 5 lots of fruit were kept for 5 days at temperatures ranging from 35° to 80° F. The results confirmed those of experiments mentioned in a former report.[2] It was found that stem-end rot can

[2] Porto Rico Sta. Rpt. 1920, pp. 27–36.

be arrested by cooling the fruit immediately after it is packed, and by keeping it at a temperature of about 45° F. Although infected fruit can be kept at this temperature without decaying, it will rapidly decay as soon as it is removed from the refrigerator.

In order to determine whether precooling can be used to advantage when fruit is to be shipped on nonrefrigerated steamers, 500 boxes of fruit were cooled to 50° F. and then stowed in a compartment of a nonrefrigerated steamer. As a result of observations made of the changes taking place en route and the condition of the fruit upon its arrival in New York, it was concluded that fruit should be cooled to a temperature of between 35° and 40° F. and transferred directly from the refrigerator to an insulated hold of the steamer. The hold should be filled, and likewise provided with ventilation to permit of the removal of moisture and carbon dioxid. When these precautions are taken the temperature of the hold will hardly rise above 60° F. during the trip from Porto Rico to New York.

ONIONS

Although the Bermuda onion is produced in Porto Rico in commercial quantities, its cultivation is not very remunerative, because the crop is not exported and the supply is greater than the demand. The writer therefore made a study of the market conditions in New York while he was there in connection with the precooling experiments previously mentioned. The data obtained show that for many years the price of Bermuda onions has been high in March. Growers are urged to use the best seed obtainable, plant for early maturity, and use standard field and packing methods in order that they may market the crop at remunerative prices.

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PORTO RICO AGRICULTURAL EXPERIMENT STATION
MAYAGUEZ, P. R.

Under the supervision of the
UNITED STATES DEPARTMENT OF AGRICULTURE

REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION

1924

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PORTO RICO AGRICULTURAL EXPERIMENT STATION, MAYAGUEZ

[Under the supervision of the Office of Experiment Stations, United States Department of Agriculture]

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[1] Appointed July 15, 1924. [2] Appointed Feb. 18, 1924.

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REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION, 1924

CONTENTS

REPORT OF THE DIRECTOR

By D. W. May

Although Porto Rico was settled by Europeans a century before permanent settlements were established on the mainland, the agriculture of the island was in a low state of development when the agricultural experiment station was established in 1902. As a consequence, the experiment station was unable to confine its efforts to research, which is its legitimate function, and was of necessity forced to do much pioneering work in the introduction of new methods, growing of new crops, and improving old ones. With the establishment of the insular department of agriculture in 1917 and the development of its resources and capabilities, it gradually became possible for the station to turn over to the new department the extension activities and to devote its energies to problems of research connected with tropical agriculture. That progress has been made and Porto Rico agriculture is on a higher plane than formerly is abundantly shown in the great increase noted in all lines of agricultural production.

The cost of research is increasing, although the income of the station is almost stationary. Research in tropical agriculture is comparatively new, and there are no limits to its possibilities. Men are desired at the station for urgently needed investigations, and when secured they should be encouraged to remain with the work until the problems are solved. This will require a larger income for equipment and salaries than has been given the station.

No essential changes were made during the year in the lines of work of the station. A new department was established, with Dr.

Gerard Dikmans at its head, to carry on research with parasites affecting domestic animals. On account of the presence of certain diseases, the successful raising of pigs, goats, and chickens is made very difficult.

W. V. Tower, entomologist of the station for some years, resigned to accept a position at a higher salary with a corporation engaged in growing and manufacturing tobacco. Mr. Tower's work with the cigar beetle was so successful that certain private tobacco concerns found it profitable not only to follow his methods but to employ him to carry them out.

Thomas Bregger, plant breeder, resigned to accept a similar position with the Argentine Government. Robert L. Davis, formerly connected with the Bureau of Plant Industry, Fiber Investigations, United States Department of Agriculture, and later privately engaged in breeding flax, was appointed plant breeder.

W. P. Snyder, assistant plant breeder, resigned to continue his collegiate studies at the University of California.

SUGAR CANE

Considerable time was devoted to sugar cane, the leading crop of the island. The entrance of sugar duty free to the markets of the mainland has, in many instances, induced planters to grow cane to such an extent as to neglect rational systems of cultivation. Large mills are necessary in cane production, and when cane lands are devoted to other crops this valuable equipment is likely to lie idle and to deteriorate. Cane will therefore continue to follow cane, and problems arising in connection with its cultivation will have to be solved not so much by changing the crop as by changing the variety on a given area or the system of fertilization. Results obtained at the station show that, next to the practice of rotation, a change of varieties is advisable. Growing immune varieties proved to be the most successful means of combating the mosaic disease, which for a time threatened the sugar industry. At the time the disease became pronounced the station distributed over the infected areas immune or highly resistant varieties which were obtained from various sources. The work of the station in averting complete ruin of the crop was appreciated by cane growers in the section receiving the greatest benefit from the introduced varieties, as was shown by their presentation to the station of a cup, and a memorial reading as follows:

MEMORIAL OF THE AGRICULTURISTS OF THE WESTERN PART OF PORTO RICO TO THE PORTO RICO AGRICULTURAL EXPERIMENT STATION

Whereas the sugar industry in this part of the island was menaced with ruin on account of the mosaic disease, which had invaded its cane fields;

Whereas the Porto Rico Agricultural Experiment Station, of the United States Department of Agriculture, introduced in 1919 some barrels of cuttings of Uba Natal cane, commonly known as Kavangire, or Japanese cane, which is immune to this disease;

Whereas from these seeds were propagated the extensive cane fields now existing in all this region and the industry was thus saved from destruction: Be it therefore

Resolved, By the undersigned, to present this memorial to the Porto Rico Agricultural Experiment Station in testimony of gratitude and in remembrance of the success achieved in the furtherance of its honor and of our welfare.

Mayaguez Sugar Co. (Inc.); M. Fajardo; Enrique Vivoni; Juan Ortiz Pericchi; Central Eureka (Inc.), M. Fajardo, President; Central Coloso (Inc.), Gmo. Cabrera; Ana Maria Sugar Co., pp. R. Valdés; Sucs. de R. Valdés, R. Valdés; Enrique Lopez Delgado; Juan A. Monagas; Juan Angel Tió; Alfredo Ramirez; Russel & Co., Sucs. S. en C.; Sucs. de Bianchi; Jaime Annexy, jr.; Celedonio Carbonwell, pp. Manuel Alcaráz; Rodolfo Colberg; Juan Acarón Correa; Clemente Javierre.

These so-called Japanese or Indian canes are not of the highest quality, but were used as emergency canes to ameliorate the conditions which were brought about by the mosaic disease. The station is endeavoring by breeding and importation to establish resistant canes which will be richer in sucrose and can be harvested at less cost than those now under test. The results are most encouraging, some of the hybrids proving not only immune, but easier to mill and of a higher quality than are the Indian canes. The greatest contribution the station can make the sugar industry is through breeding canes of higher tonnage, greater sweetness, and resistance to disease. Thousands of seedlings are bred annually, and some of them are of outstanding merit. The highest yield on the island, at the rate of 8½ tons of sugar per acre in one case, and, in another case, 81 tons of cane per acre, was made by the variety St. Croix 12/4, which originated at the Virgin Islands experiment station.

The rapidity with which a new variety of cane can be spread over a given area within a limited time is remarkable. Some of the best varieties have been introduced as single cuttings. A single cutting will produce by stooling 10 to 50 canes, which will mature in the first year. These canes will have sufficiently grown for planting in six months and will furnish 50 to 250 cuttings. Cut again in six months, they will provide cuttings for planting a considerable area. Thus it can be seen how quickly a planter can change his fields to a new and better cane. The station distributes tried and promising varieties in small quantities and without cost to different planters over the island to prove the merits of the variety under local conditions and to encourage planters to grow their own seed cane. This arrangement relieves the station of having to use its limited funds for commercial purposes rather than for experimentation, and it often enables the planter to sell his seed at a higher price than is paid at the mill.

GERMINATING SUGAR CANE

In Porto Rico it is seldom necessary to keep cuttings of cane for any great length of time before planting. Cane growing is a continuous process, the new planting being made as the old one is cut. However, only sound, clean cuttings should be planted, and these should be given a quick start to enable them to make good growth. Too frequently the cane borer (*Diatræa saccharalis*) is introduced with the cuttings. All infested cuttings should be soaked in a solution before planting. The solution readily enters the channels left by the borer and drowns it. This alone would justify soaking

the seed before planting, even when the borer is present in only small numbers. If there is added to the solution an element which is stimulating to plant growth, the crop will not only be free from borers but will make an increased growth. A series of experiments was made at the station to determine the effect on germination and growth of soaking cane cuttings in solutions of various kinds. Prior to planting, the cuttings (seed) were soaked for 24 hours in water, saturated limewater, and limewater and magnesium sulphate. The water-soaked seed gave a germination of 86.42 per cent, the dry-planted seed only 81.41 per cent. A still higher germination, 93.03 per cent, was made by the cuttings which had been soaked in limewater. At the end of three months the dry-planted cane had made a growth of 164 inches, the water-soaked 180 inches, the limewater-soaked 202 inches, and that soaked in limewater and magnesium sulphate 220 inches. The final yields of the plats were as follows: Cane, planted as cut, 58.7 tons per acre; soaked in water, 71.9 tons; soaked in limewater, 72.5 tons; soaked in water containing lime to saturation and 1 pound of magnesium sulphate to 50 gallons, 85.4 tons. The increase in growth of the soaked over the dry-planted cane was due not only to the destruction of the borer but also to the influence of moisture on germination. Where chemicals were used in addition to the water, there was a neutralization of the cane juices which tended to prevent their rapid fermentation and to conserve their stored food, to be used by the growing plant as needed.

LIVESTOCK

The livestock of the island, especially the dairy cattle, are increasing in numbers and in quality, partly through the introduction of purebred animals and partly through crossings of the native stock with improved sires, as exemplified by the station. As a result of judiciously crossing native cows with purebred bulls, the station has developed a herd some of which carry fifteen-sixteenths Guernsey blood. Dairy capacity has increased with each succeeding generation. The native cows of the foundation herd yielded on the average 8.09 pounds milk per day per cow; the second generation (half-bred cows), yielded on the average, 11.9 pounds per day per cow; and the third generation (three-quarters bred), 13.5 pounds per day. (Fig. 1.) This shows an increase of 47 per cent for the half-breds over the native, and 13½ per cent gain for the three-quarters bred over the half-bred. The results have been so favorable and at such a small risk of loss that planters are advised to import only bulls for breeding up the native stock. Both sexes can be acclimated by careful handling, but under the present conditions and methods of management it is best to confine the purchase to the best bull obtainable. Purebred herds can be introduced when the cattle tick has been eliminated and the farmer is prepared to give his cattle good stabling and feed.

The station now owns three purebred Guernsey bulls from dams that have yielded 12,000 to 13,000 pounds of milk annually. These bulls are well fed, and kept stabled except when they are made to work for exercise. Young bulls should be broken to work with native oxen. Work gives them needed exercise and likewise helps in their maintenance. Purebred bulls are supplanting native work cattle in

all farming operations at the station. During the year 79 cows, in addition to those at the station, were bred to these bulls.

Dairy practices are improving. Fresh milk continues to bring relatively high prices, retailing in Mayaguez at 20 cents per quart. A surplus of this commodity could perhaps be used to best advantage in the form of cheese for home consumption and for the local market. Canned dairy products find a ready market in Porto Rico, but they never equal the fresh article. The value of cheese imported into the island in 1921 was $777,638. With the establishment of a race of cattle giving larger milk yields than are now obtained and the successful growing of forage crops, assuring a plentiful supply of nutritious feed for the cattle, there should be rapidly developed a profitable cheese-making industry which will be comparable with that of any other country.

FIG. 1.—Three-fourths grade Guernsey cow. Milk yield 5,000 pounds, butterfat 300 pounds, per year

An increase in the production of forage grasses is primarily the cause of the increase in the number of cattle now found on the island. To promote the livestock industry, the stockman must grow an abundance of feed for his herd. Elephant grass, Guatemala grass, and velvet beans make rapid growth, are greatly relished by cattle, and have high value as stock feed. Such crops are converted into beef, milk, and butter, with the least expenditure of energy and money.

SILOS AND SILAGE

The station built the first silo in Porto Rico in 1908. Since then a number of silos have been erected, especially along the south slope, where the rainfall is deficient. Corn, cane, malojilla grass (*Panicum barbinode*), elephant grass (*Pennisetum purpureum*), Guatemala grass (*Tripsacum laxum*), velvet beans, and cane tops have been

ensiled at the station. Corn made the best silage, comparing in flavor and palatability with that made in the Temperate Zone. Cane came next, but gave trouble during the fermentation process. Its high sugar content is conducive to the production of alcohols and acids, and the processes are difficult to halt. Even with cane tops, fermentation passed from the alcoholic to the acetic stage when there was too much moisture, and it did not take place at all when the tops were too dry. The grasses and velvet beans made poor silage, due largely to the fact that they are too light to pack well unless heavily weighted. The grasses lacked sufficient juice to ferment well, and the resulting product was dry and developed a musty odor. The velvet beans were juicy enough, but they were either not of the proper composition or the proper quality for silage making, and the resulting product was black and unsavory.

Cattle differ markedly in their liking for silage, some taking readily to it and others scarcely at all. It is probably eaten more readily in the Temperate Zone because it is usually fed in winter, when no green fodders are available. Silage is of doubtful value at the station, where the annual rainfall is fairly well distributed, and green forage usually available throughout the year. Even when it was well made the station animals ate it with reluctance, wasting 75 per cent of the grasses and 55 per cent of the sugar cane. Results of experiments show apparently no difference between silage made in the Tropics and that made in the Temperate Zone. Corn silage has been carried over at the station for two years with good results.

PEAS

Peas are not found in the markets or even in the home gardens of Porto Rico, and attempts to grow them at the station were unsuccessful until they had been inoculated with the proper nodule-forming bacteria obtained from the United States Department of Agriculture. Since then a large number of garden and flowering varieties have been grown with ease. Dwarf and climbing peas grow equally well, but the latter make larger yields and over a much longer period. They should be given support, preferably with bamboo stakes or woven-wire fencing, to make the best yields. Many varieties of sweet peas grow well, but the late or summer-flowering sorts fail to bloom, very probably because of the small variation in the length of day in the Tropics. The early-flowering sweet peas bloom profusely; however, they do not make so large a vine growth as the summer-flowering varieties. Peas may be grown in young cane, both plant and ratoon, and are adapted to growing with corn. The crop provides excellent forage for the work animals, and even when not harvested will greatly improve the soil for cane growing. Pea seed should be inoculated with nitrogen-fixing bacteria before it is planted, or else it should be mixed with inoculated soil, which can be obtained from the station for the purpose. After the soil is once inoculated, the process need not be repeated.

REFORESTING

During the year 60 acres of land were planted with seeds and seedlings less than a year old of many forest trees, including palo

de Maria (*Calophyllum calaba*), caoba (*Swietenia mahagoni*) (fig. 2), maga (*Thespesia grandiflora*), ipil-ipil (*Leucæna glauca*), obtained from the Philippines, flamboyan blanco (*Bauhinia kappleri*), acacia amarilla (*Albizzia lebbeck*), *Eucalyptus robusta*, and Australian pine (*Casuarina equisetifolia* and *C. cunninghamella*), the seed of which was introduced. Approximately 10,000 mahogany trees and others of economic importance are now growing on the 200-acre tract on the mountain overlooking Mayaguez. Palo de Maria makes the best growth under the most adverse conditions, is valuable as a cabinet wood, and can be recommended for commercial planting.

The soil on which the forest trees have been planted is very variable. At the station proper, it is an undulating clay of average

FIG. 2.—Mahogany trees 15 years old on the Mesa, near Mayaguez. Elevation, 1,000 feet

quality; and, on the area ranging from 500 to 1,000 feet above sea level, where the greater part of the plantings are, it is for the most part ferruginous, in places consisting of more than 50 per cent ferric oxid. In these places, it is difficult to get anything to grow. Results of experiments at the station indicate that legumes may be grown with advantage on reforested areas. Nurse crops, such as the pigeon pea or the dwarf bucare (*Erythrina berteroana*), which grow readily from cuttings, are especially valuable for reclaiming badly washed soil and windswept ridges. They not only store nitrogen in the soil but also furnish temporary wind and sun protection for the more tender seedlings. A nonclimbing legume is perhaps best as an intercrop for young trees. Crotalaria is very good for the purpose, and can be followed by velvet beans when the trees are past danger of being smothered out.

REPORT OF THE ASSISTANT CHEMIST

By J. O. Carrero

No new work was started in this division, it being expected that every available facility will be taxed to the utmost when the crops are gathered. Certain material of a highly perishable nature will require immediate attention, and the composition of the soils under treatment will need to be determined as soon as samples are taken.

MANAGEMENT OF CANE SOILS

The study of nitrogen utilization by cane soils was continued. The first ratoon crop was cut early in the year, and the residue, after being allowed to dry, was either incorporated with the soil or burned off, depending upon the kind of treatment given each plat. Samples were taken of soils to be limed, and the plats were given the required treatment, followed by plowing and the planting of a leguminous cover crop which was turned under. Later, the land was disked and harrowed and in July was planted with cane. Certain of the plats were fertilized with nitrogen in the form of nitrates three weeks later, and others were left to serve as checks. Early in the experiment, differences in height and color of plants were observed between the nitrogen and the control plats, and small differences in height but marked differences in color were apparent between the sodium nitrate and the ammonium-sulphate plats. At present, 13 months after planting, hardly any difference is to be seen either in height of cane or color of leaves, regardless of the form of nitrogen applied, while large differences, both in height and thriftiness of plants, are noticeable between the nitrogen and the control plats.

In a series of experiments made to determine the comparative yields of cane plats under different treatments, certain sections (series A, C, and E) were limed, and others (series B, D, and F) were left unlimed to serve as checks. Plats Nos. 1, 2, 3, and 4 of the C and D series were treated with nitrogen as sodium nitrate at the rate of 60 pounds per acre; plats Nos. 5 and 6 of the C and D series were given nitrogen in the form of sodium nitrate at the rate of 30 pounds per acre; plats Nos. 1, 2, 3, and 4 of the E and F series received 60 pounds of nitrogen as ammonium sulphate; and plats Nos. 5 and 6 of the E and F series, nitrogen in the form of ammonium sulphate at the rate of 30 pounds per acre. No plats in the A and B series received nitrogen. In plats No. 1 of all the series the trash was burned, but no legumes were planted; in plats No. 2 the trash was burned and legumes were planted and plowed under; in plats Nos. 3 and 5 the trash was plowed under, but no legumes were planted; and in plats Nos. 4 and 6 both the trash and the legumes were plowed under. The following table gives the results of the test:

Comparative yield of cane plats under different treatments

Plat series	Plat number	Plant cane per acre	Cane per acre from first ratoon	Available sucrose per acre from plant cane	Available sucrose per acre from first ratoon crop
Limed:		*Tons*	*Tons*	*Tons*	*Tons*
A	1	25.29	20.74	3.537	2.188
	2	28.36	22.02	3.880	2.853
	3	24.78	18.00	3.466	2.171
	4	25.17	26.50	3.378	3.136
	5	10.50	21.93	1.242	2.327
	6	19.29	25.12	2.384	2.625
C	1	41.58	21.37	4.700	2.827
	2	48.52	36.25	5.804	4.510
	3	43.20	28.63	5.752	3.526
	4	46.34	33.47	5.061	3.756
	5	38.14	20.64	4.726	2.319
	6	37.58	29.62	4.669	3.393
E	1	38.62	20.52	4.648	2.458
	2	47.58	30.06	5.507	3.006
	3	42.42	23.76	5.553	2.713
	4	40.78	30.37	4.973	3.708
	5	34.87	27.15	3.738	3.232
	6	36.35	34.07	4.660	4.227
Unlimed:					
B	1	37.99	23.18	5.233	2.965
	2	37.34	25.60	5.087	2.960
	3	33.47	21.10	4.204	2.403
	4	37.05	29.48	4.771	3.146
	5	32.33	17.91	4.243	2.208
	6	35.94	28.75	3.783	3.394
D	1	43.12	24.39	5.418	3.000
	2	49.83	33.42	5.807	3.700
	3	40.70	27.68	5.000	3.405
	4	47.84	35.45	5.400	3.841
	5	39.16	27.52	4.792	3.276
	6	43.10	38.74	5.505	4.748
F	1	38.70	38.28	4.427	4.230
	2	42.16	33.76	5.243	3.208
	3	44.72	30.15	5.274	3.373
	4	35.33	37.80	4.405	3.023
	5	42.76	22.60	5.433	2.540
	6	37.12	27.13	4.214	3.500

Velvet beans and cowpeas have been the only crops so far tested in this experiment to determine the extent to which they utilize atmospheric nitrogen. Cowpeas, velvet beans, *Crotalaria* sp., and sweet clover are also to be tested further. Comparative tests are under way to determine the amount of nitrogen and other fertilizers removed by the crop and the effect of the treatment applied on soil composition.

EFFECT OF SULPHUR AND SULPHUR COMPOUNDS ON PORTO RICAN SOILS

Results of preliminary experiments with sulphur and materials carrying sulphur in soluble form failed to indicate any increase in plant growth due to added sulphur. In comparative tests, made on a red clay soil, with and without the addition of lime, native bat guano was found to contain enough sulphur in soluble form to more than satisfy the needs of the plants. In a second test the fertilizers applied lacked sulphur either in a soluble or insoluble form in the control pots. The test pots were treated with sulphur or calcium sulphate to observe their effect on plant growth. Sulphur failed to produce any increase in yield regardless of whether the soil was limed or unlimed when nitrogen and potash were the fertilizers

added. Calcium sulphate failed to bring about any increase in yield in the unlimed pots, but doubled it in the limed pots. When phosphoric acid was used with nitrogen and potash the addition of calcium sulphate always produced an increase in yield, the limed pots producing the largest increases. When no sulphur was used the yield of the limed pots was below that of the unlimed pots. However, the addition of calcium sulphate to the limed pots produced a yield which fairly equaled that in the unlimed pots.

ANALYTICAL WORK

Irrigation and drinking waters, feeds, fertilizers, minerals, and other materials sent in from various sources were analyzed when it was thought the results would be of general interest or importance. Analytical work was also done for the other departments of the station, including the analysis of the juices of recently introduced varieties of cane and seedling canes for the assistant horticulturist. Comparative studies were made of the composition of the juices of Uba cane and Java Unknown when the crops were harvested at different periods of maturity, and of the deterioration occurring in the juices after the canes were cut and left on the field for several days. Notes were made of the changes in the Brix hydrometer reading of the juices, sucrose content, purity of juices, reducing sugars, and quantity of juice extracted from the canes under similar conditions.

REPORT OF THE HORTICULTURIST

By T. B. McClelland

EFFECT OF VARIATION IN DAY LENGTH ON GROWTH OF CERTAIN PLANTS

A large part of the year was devoted to a study of the effect of variation in day length on blossoming and growth of certain local plants. A June day length in this latitude, 13.2 hours, was found to be too long, and one of 10 hours too short, to induce blossoming of *Tephrosia candida*, a tropical legume which is used as a cover crop. Shortening the day from the long day of summer to a 12-hour length promptly induced blossoming, whereas a continuation of exposure to the long summer day inhibited it. Heavy blossoming was induced out of normal season through artificial manipulation of the length of daily light exposure, and growth as well as blossoming was affected to a pronounced degree, the longer day producing growth with longer internodes and larger leaves. Miscellaneous plants, which were grown under day lengths approximating those of June and December in this latitude, showed pronounced and interesting differences in behavior. The day was shortened to 11 hours for one group and lengthened to 13⅓ hours for the other. Although planting may be made every day in the year in Porto Rico so far as the temperature is concerned, plant growth is influenced to such an extent by any variation in normal day length as to make the planting season in many instances the deciding factor for success or failure.

Bermuda onions, grown under the short winter days, were transferred from the field while still in the "spring onion" stage, three months after planting. Thirty-three days later the bulbs in the long-

day group were more than twice as large as those growing under the reduced day length. Roselle showed buds at 4 weeks after planting under the short-day length, carried large red fruits, though only 5 inches high, at 10 weeks, and matured seed at 14 weeks. These plants remained about 5 inches high. Of the plants which were kept under the long exposure for 5½ months, the tallest attained a height of 36 to 45 inches, and none showed a tendency to blossom. These plants were still growing vigorously when those under the artificially shortened day, having fruited, were dying. (Fig. 3.) Small radishes which were taken from the field and placed in the two groups showed differences as early as 8 days after setting. The effect of day length was here most pronounced, much larger leaves and roots developing under the longer exposure to light. Zinnias blossomed under both exposures but showed decided differences. Under the shorter day they blossomed at 5 weeks, but under the longer day they required about 8 weeks. Under the short day the plants were spindling and produced numerous blossoms, whereas under the long day they grew more vigorously, attained a greater height, and had broader leaves and fewer but larger blossoms. The long day inhibited blossoming in cosmos, while the short day produced small, spindling plants which opened their first blossoms at 39 days after the seed was planted. Poinsettias behaved similarly. (Fig. 4.) Biloxi soy beans opened the first blossom at 30 days after planting under the short exposure and at 47 days under the long exposure. The former carried good-sized, well-filled pods at 2 months, while the latter, although blossoming, were as yet setting no pods. Seed matured in less than 3 months under the short exposure and the dwarfed plants at 3½ months, with crop matured, retained few leaves, made no further growth, and soon died. Five months after planting the plants under the long day were large, well foliated, and bore pods turning from green to brown. The height attained under the short day was approximately 1 to 1½ feet and under the long exposure 3 to 3½ feet (fig. 5). *Tithonia rotundifolia* developed much more rapidly under the short day. Two weeks after the plants were placed in the two groups, those under the short exposure showed an average increase in height of 8 inches, in contrast with an increase of 2 inches under the long exposure. Seed matured under the short exposure before the first blossom opened under the long exposure.

CROTALARIA SPP. AS COVER CROPS

Tests are being made with *Crotalaria* spp. to determine their efficiency as cover crops, and seed of the most vigorous growing species is being distributed to those desiring it.

ROOT CROPS

Sweet potatoes.—Approximately 40 varieties of sweet potatoes from both continental and insular sources have been under test at the station during the past four years. These have now been reduced to one of the local "mamey" or orange-fleshed varieties and nine varieties which were imported from the north, and they are considered best from the standpoint of yield and quality. Annual plantings for comparative purposes are made in 50-foot rows spaced 5 feet apart. Key West and Madeira led in production, each yielding at

the rate of little more than 15 tons per acre (fig. 6). A still higher yield—260 pounds, or at the rate of approximately 22½ tons per acre—was obtained from a 50-foot outside row of Key West, which,

FIG. 3.—Effect of length of daily illumination on roselle plants. At right, illuminated equal to June days; at left, equal to December days

because of its position, was not included in the comparisons. Owing to their superior table qualities and consistently high yields throughout the tests, one or the other of the varieties leading in production

FIG. 4.—Poinsettia plants. Right, short-day illumination; left, long day

FIG. 5.—Biloxi soy beans. Right, short-day illumination; left, long day

each year, Key West and Madeira are unqualifiedly recommended for general planting. Extensive distributions of these varieties have been made on the island.

Yams.—The yam collection has been reduced to 6 varieties which have shown themselves most valuable for this locality. Purple Ceylon led in yield, producing on the average 4 pounds 14 ounces per hill, and was closely followed by the Potato yam, with an average of 4 pounds 6 ounces per hill. The heaviest single tuber was produced by *Dioscorea alata* (S. P. I. No. 47001) and weighed 15 pounds 13 ounces.

Yautia.—To determine the effect, if any, of the form of the seed on the yield of yautia, the horticulturist planted differently shaped seed pieces of 9 varieties, using elongated tubers, short plump tubers, and tops and other cut sections of the rootstock. The pieces were as

FIG. 6.—Variety test of sweet potatoes. Key West, variety in center, yielded at the rate of over 15 tons per acre

nearly uniform in weight as possible, those of 8 varieties weighing between 70 and 110 grams and of the other variety between 60 and 100 grams. The total difference in weight of the crops from the different kinds of seed was found to be only 19 per cent, the elongated tubers leading in production, and the cut sections of the rootstock ranking lowest. The heaviest yields in 5 varieties were from elongated tubers and in 4 varieties from short tubers, the difference in weight of the totals of the two forms amounting to 10 per cent. Heavier yields were obtained from the tops of rootstocks than from the lower sections for 6 varieties, and the opposite was true for the 3 other varieties. No definite, consistent correlation was apparent between the form of seed piece planted and the weight of the crop

harvested, the elongated tubers leading in 3 cases, tops in 3, cut sections in 2, and short tubers in 1; and the elongated tubers ranking lowest in 2 cases, tops in 1, cut sections in 4, and short tubers in 2.

Dasheen and taro.—With dasheen and taro the effect of size of seed piece on the resulting yield was pronounced for the tests as a whole and consistent for each variety tested. In four varieties tubers weighing between 70 and 100 grams were used as small seeds, and tubers weighing between 140 and 200 grams as large seeds. Seed for two other varieties was slightly smaller but similarly contrasted as to relative size. At harvest time the yield from 10 seed pieces of each variety was weighed. The total increased yield from the planting of large tubers was 17 per cent and amply repaid the greater initial cost of the larger seed.

The Penang taro has demonstrated its excellent table quality and also its very poor keeping qualities. It is a highly desirable variety for the home garden, but its perishability is greatly against it as a commercial product, a large percentage of the corms rotting within a week after digging.

AVOCADO

Of the various methods of propagating the avocado, those described as slot grafting[1] and bottle grafting[2] may be of interest to avocado growers in Porto Rico. In slot grafting (fig. 7) the scion is tapered to a wedge shape with a long, oblique cut, and then inserted under an upright tongue of bark which has been cut to fit closely, both tongue and scion being held in position by a fine brad driven through the graft into the wood of the tree. The scion and exposed surfaces are then coated with paraffin, which is sufficiently warm to spread. In bottle grafting, an oblique slit is made well up on a long scion, which is then placed saddle fashion on a stock that has been cut in the form of a wedge, the union being secured by waxed tape. The base of the scion is immersed in water until the new growth has developed and hardened. (Fig. 8.)

COFFEE

Fertilizer experiments with coffee were carried on as previously outlined. Potash and nitrogen continue to show themselves more effective than acid phosphate in increasing yield, the former each appearing seven times and the latter three times in the fertilizer combination applied to the 10 plats making the best yields of the 40 included. In a cooperative experiment a 7:7:7 fertilizer gave a substantial increase in crop in the past year following semiannual applications at the rate of 350 pounds per acre. In experiments comparing sulphate of ammonia and nitrate of soda in combination with acid phosphate and potash, plats receiving the former yielded in the 1923 crop 7¼ liters of cherries per tree, whereas those receiving the latter produced 4½ liters, which is in accord with their previous performance. An extensive pot test has been begun to investigate further the apparent superiority of sulphate of ammonia over nitrate of soda as a fertilizer for coffee. Applications of nitrate of soda are made semiannually in some instances and monthly in others, and with and without sulphur, all with corresponding checks.

[1] Jour. Heredity, 14 (1923), No. 9, p. 399. [2] Idem., No. 4, p. 171.

HIBISCUS

Over 500 hibiscus seedlings, some of striking beauty, are growing at the station. Most of them are the result of crosses between recently imported and locally grown varieties, and approximately 100 are the progeny of a Hawaiian introduction (Hawaii Sta. No.

FIG. 7.—Slot-grafted avocado, 140 days after placing scion

205:2) pollinated with *Hibiscus schizopetalus*. The former bears small white to straw-yellow flowers in which the eye is carmine, and the latter flowers shading from bright rose to carmine. The seedlings from this cross are of very vigorous habit and show a wide

range of growth, foliage, and form and color of flowers, the latter ranging from very pale tints of pink and salmon through the scale to red and carmine. The range in variety would seem to fall not far

FIG. 8.—Bottle-grafted avocado, 50 days after placing scion

short of the number of individuals, involving in the flower, size, shape, scalloping of petals, absence or presence and size of eye, tinting or shading and blending of colors on both upper and under surface of petals, and color of stigma. (Fig. 9.)

REPORT OF THE ASSISTANT HORTICULTURIST

By José A. Saldaña

SUGAR CANE

Two recently introduced varieties of sugar cane—B 14761 and Mauritius Seedling—show considerable susceptibility to the mottling and root diseases. The variety E. K. 28 from Java continues to do

Fig. 9.—Flowers of Hibiscus crosses. Flowers of parent species at top

well, although it requires very well-drained soil for best development. Another of the introductions is an unidentified variety called "Java Unknown," which is supposed to have come from Java. It is very similar to Uba, Cayanna–10, and Zwinga, but can be distinguished from them by its swollen nodes, heavier stooling habit, darker green leaves, and by the ease with which it may be stripped. In a comparative test with Uba it yielded 55.52 tons of cane per acre, whereas the Uba yielded at the rate of 49.19 tons. The following table gives the average results of a series of analyses of these two canes:

Chemical analyses and calculated yields of Java Unknown and Uba cane[1]

Name of cane	Brix reading	Sucrose content	Coefficient of purity	Total juice extracted by small mill	Calculated yield of sugar per acre[2]
	Degrees	*Per cent*		*Per cent*	*Tons*
Java Unknown	18.38	14.45	78.60	55.61	5.334
Uba	17.75	14.55	82.36	57.79	5.019

[1] The analyses were made when the canes were about 16 months old.
[2] Calculations based on 76.79 per cent for Uba and 74.61 per cent for Java Unknown, as extracted by the larger mills. The latter variety was little over 2 per cent lower in extraction than Uba.

The variety P. O. J. 2725, a Java cane which was received from Tucumán, Argentina, shows high resistance to the mottling disease and produces a large number of canes to a stool. In general, it is considered a promising variety.

Of the 8,000 seedlings which were set in the field, only 18 were selected for further testing, the others being discarded because of susceptibility to the mosaic disease or of inferiority to the parent varieties. Most of the seedlings were from P. R. 359, which, because of its susceptibility to mosaic disease, does not appear to be desirable for additional breeding work. In the fields of P. R. 359, from which arrows were collected, the mosaic infection was 100 per cent. The resulting seedlings did not develop the disease directly, but nearly all of them got it by secondary infection.

The following list gives the number of seedlings produced by the different varieties in 1924: D 109, 28,000; P. R. 492, 380; B 6308, 151; G. C. 1486, 135; B 3412, 89; S. C. 12/4, 76; Rayada, 63; P. R. 409, 34; E. K. 28, 18; P. R. 449, 9; P. O. J. 36, 5; P. O. J. 105, 2; and F. C. 306, 1. Of a total of 28,963 seedlings, only 2,100 selected specimens were set in the field.

Some of the varieties which were tested between 1920 and 1924 have shown complete or partial sterility. The Uba cane, proving male sterile, was considered adapted to cross-pollination with pollen-fertile varieties. The varieties P. O. J. 36, P. O. J. 105 (Egyptian), and F. C. 306 gave very poor germination. Cayanna–10, D. 433, and Cristalina did not germinate at all. The varieties giving a fairly good germination included E. K. 28, S. C. 12/4, G. C. 1486, B. 6308, P. R. 409, P. R. 449, Rayada, B. 3412, B. 1809, B. 4596, P. R. 292, and P. R. 358. Those giving excellent germination were D. 109, P. R. 359, and P. R. 492.

TOMATOES

Of the varieties tested during the year, Trucker Favorite and Matchless were the most susceptible to bacterial blight, the crop being destroyed before the yield could be determined. Cristobal produced on the average 2.86 pounds of fruit per plant and Hawaiian Hybrid 2.97 pounds, during a comparatively short period, then succumbed to blight. Burpee Self-Pruning produced a fair crop, approximately 2.94 pounds of fruit per plant, but proved susceptible to attack by blight and Phytophthora. Dwarf Stone showed some resistance to blight, and Stark Blight Resister (probably same as Norton), which yielded fairly well, proved markedly resistant to disease, being one of two varieties to yield for the longest period. The varieties Greater Baltimore, New Century, Trophy, Ponderosa, Imperial, Stone, Lares Smooth, and Arlington have been under test for two years. Of these, New Century, Greater Baltimore, Lares Smooth, Stone, Imperial, and Arlington are the best yielders. Hybridization done in previous years included crosses between Prolific and Stone, Greater Baltimore and Lares Native, Arlington and Greater Baltimore, Lares Native and Stone, New Century and Insular Station No. 433, and Insular Station No. 433 and Diener. From the above crosses strains have been selected and tests made each year under adverse and favorable conditions. Of the selections tested this year on land on which several crops of tomatoes had succumbed to blight, the hybrids obtained by crossing Insular Station No. 433 and Diener 1–10 proved to be the most resistant to bacterial blight. This strain is very prolific, yielding at the rate of 3.89 pounds of fruit per plant and bearing large clusters of small-sized fruits which are suitable for marketing. The progeny of Lares Native × Stone, Greater Baltimore × Lares Native, and New Century × Insular Station No. 433, from which the bitter flavor of the native parent has been eliminated, are doing fairly well.

MUSKMELONS

In December, 1923, two selections each, from a native muskmelon crossed with Salmon Tint Pollock and with Casaba, were set in hills 2 feet apart in beds 7 feet apart. The plat was treated with a mixture of sodium nitrate (3 parts), phosphoric acid (4 parts), and potassium sulphate (1½ parts), applied at the rate of 4 ounces per hill, and the plants were sprayed with nicotine sulphate (4 cubic centimeters of the sulphate to 1 gallon of water) for plant-lice control. Cycospora and downy mildew attacked the plants and caused premature fruiting. Seed for further planting was saved from hybrids showing the most resistance to mildew. Notes were taken on earliness, vigor, weight, number, ribbing, netting, and shape of fruit, and color and quality of flesh. One of the hybrids of the native melon crossed with Casaba shows considerable uniformity in plant and fruit characters, but the fruit lacks flavor. A hybrid of the native melon crossed with Salmon Tint Pollock is not only prolific but the flavor of its fruit is all that can be desired. Selected seventh generation hybrids of both crosses, planted in April, 1923, and sprayed with Bordeaux mixture for fungus control, produced fine crops. The fruit of the native melon crossed with Casaba continues to lack flavor,

however, whereas that of the native variety crossed with Salmon Tint Pollock has good flavor and weighs 3 to 7 pounds each. Some of the hybrids inherited the size, shape, and ribbing of the native melon and the sweetness of Salmon Tint Pollock, and others, the shape, netting, flavor, and smoothness of the Salmon Tint Pollock and size which is intermediate between that of both parents. The fruit of the Salmon Tint Pollock weighs on the average 2¾ pounds, and that of the native muskmelon 7 pounds.

SWEET CLOVER

Hubam clover, an annual variety, and Bokhara, a biennial, make thrifty growth at the station, especially during the rainy season. Hubam does well even in the dry season when it is sufficiently irrigated.

PAPAYA

Plantings of papaya seed, from various local sources, are being made to isolate, if possible, a hermaphrodite type yielding a heavy crop of fruit of good quality, uniform shape and size, and proving resistant to nematodes and disease.

REPORT OF THE PLANT BREEDER

By R. L. Davis

FIELD CORN

The material used in the 1924 field-corn experiments consisted largely of ear-to-row selections which were left by the former plant breeder, and ears collected this season from the western part of the island. At the time the collection was being made it was learned that drought had ruined the corn crops in the Lajas district during five successive years. Experiments were therefore started with corn to test its drought-resistant properties. Drought-resistant varieties would be of decided advantage even in the rainy sections of the island, as at the station, where dry periods of five to eight days' duration are likely to occur during the growing season. A short dry period in the Tropics is serious because of the excessive rate of evaporation of moisture from both plants and soil. Porto Rico corn is injured by drought in the seedling stage and in the silk. The seedling stage was chosen as the most convenient one for study. Germination flats were filled with equal quantities by volume of river sand and watered to saturation. From each ear a 50-seed sample was planted an inch deep in rows and kept watered to saturation until the corn was 8 days old. The foliage of half of each sample was cut and weighed separately and the remainder was placed under a glass roof and deprived of water for eight days. Marked differences in ability to resist wilting were noted in the seedlings of the various parent ears. Nor were the differences governed by weight of foliage, several of the strains having the largest amount of foliage by weight resisting wilting several days longer than all others.

It was then thought advisable to determine the extent to which germination under field conditions would confirm results obtained under laboratory conditions. Strain No. 276–19, the second best

yielder in 1923 and a partially drought-resistant sort under laboratory conditions, was used as a control. Seeds of the check variety were sown a foot to the left of each hill of all the ear-to-row selections; hence, at two weeks after planting, each corn seedling could be compared directly as to degree of drought injury with a seedling of the check variety grown practically in the same hill. (Fig. 10.) During June, 1924, when the field planting at Mayaguez was a week old, a drought set in which lasted during the second week and made conditions strongly paralleling those of the artificial drought in the laboratory. Espiral and Gigante, the two most susceptible strains under laboratory conditions, were practically eliminated by the stunting effect of the drought in the field. On the other hand, Cacique–4 and Medio Cacique–6, which withstood the

FIG. 10.—Drought injury to corn 14 days old. On right, variety Espiral injured and failed to mature. On left, variety No. 276–19, which escaped with little injury

artificial drought, were scarcely injured by the field drought. Of all the strains tested in the spring parent ear Cacique–1 was the most resistant to drought under both laboratory and field conditions.

The outcome from the yields of shelled corn confirm the fact that ears producing seedlings which wilt readily when deprived of water under laboratory conditions are undesirable for planting. (Fig. 11.) Thus, Espiral and Gigante, which produce strongly susceptible seedlings, yielded 28.4 and 30.8 bushels of shelled corn, respectively, per acre, while Cacique–4 and Medio Cacique–6 yielded 35.7 and 37.2 bushels, respectively. Cacique–1 again demonstrated its superiority over other varieties as a drought resister and yielded 42.2 bushels or over one-third more shelled corn per acre than did either Espiral or Gigante. In fact, Cacique–1 outyielded all the other corn ears tested this season by a clear margin of 5 to 14 bushels.

Cacique–1 was according to appearances the most promising ear selected from the very dry district near Lajas. At one week the root system of Cacique–1 seedlings averaged several inches longer than those of the other ears, including those grown at Mayaguez in 1923 and those selected from the corn fields near Lajas. The foliage of the Cacique–1 seedlings ran one-third to one-half again as heavy as seedlings of other ears. The ear itself, a tapering 12-rowed one with very small cob and very long keystone kernels, was a type much favored by farmers in the Lajas district because of its ability to make a crop during years of drought. The individual kernels were shallow dimple dent with a white cap encompassing on the average about 10 per cent of the kernel. The color of the kernels varied from cadmium yellow to orange (Ridgway's color standard).

Fortunately, on the strength of the favorable appearance of the ear and the vigor of the seedlings, a special breeding plat had been

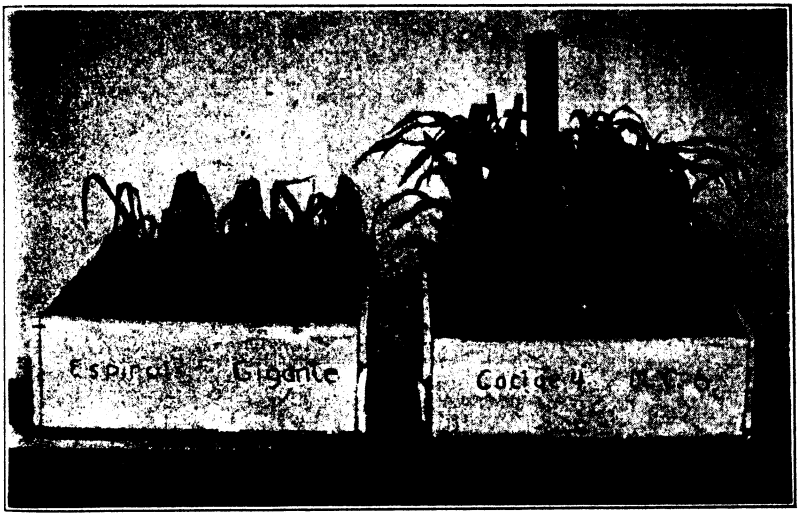

FIG. 11.—Corn 14 days old, one week after being deprived of water. Showing effect on different varieties

planted to Cacique–1 alone long before the yields of shelled corn were available. One hundred and fifty selfed lines of Cacique–1, the best yielder in 1924, have been started and foundation stock for building up a high-yielding variety for Porto Rico is already in the making.

SWEET CORN

The former plant breeder left a number of sweet-corn hybrids with native field corn. All sweet-corn seed failed to germinate excepting sugar kernels from No. 276, a native field corn selected in 1921 from near Lajas. In 1922 several ears from this strain were found with 10 to 20 kernels segregating into sweet and starchy types. It is not known whether the strain is the result of chance pollination from some variety of sweet corn grown in rural school gardens or whether it is a sport or mutation from the native field corn. The sugar kernels from the 1923 crop of these ears were sorted out and

formed the basis for the 1924 breeding work. The samples were rogued in the germination boxes and resulting vigorous seedlings with long roots and healthy green leaves were transplanted to the field. Just prior to tasseling all unhealthy plants were again rogued. The remaining plants reached a height of 6 to 8 feet and produced ears which were 4 to 7 inches long and well filled to the tip with sweet kernels. (Fig. 12.) Introduced varieties of sweet corn do not attain a greater height than 3 to 4 feet and produce ears which are rarely more than 3 to 4 inches long and soon become worm-eaten.

The original crossbreeding work was between Henderson Sugar and a white native field corn. This was run through four genera-

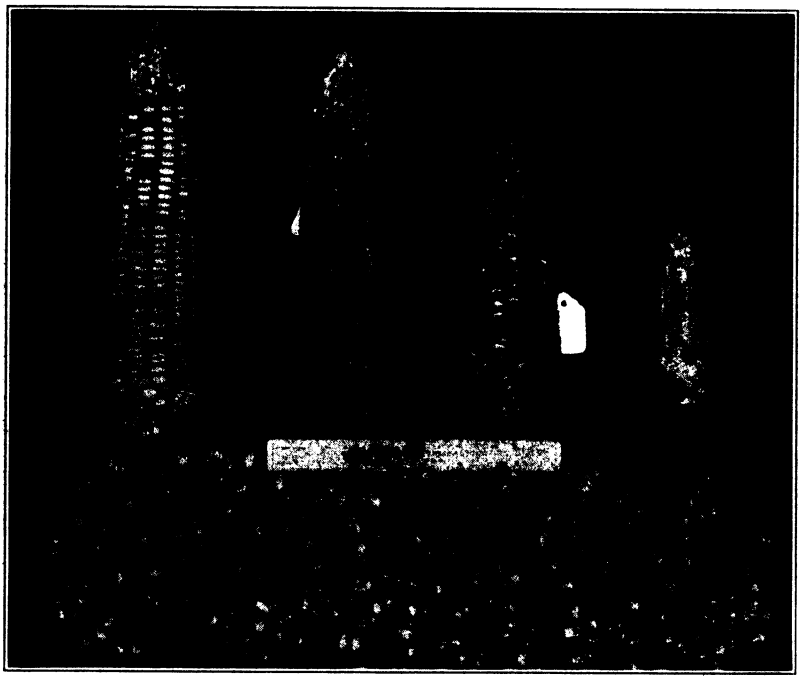

FIG. 12.—Sweet-corn improvement. On right, usual type of sweet-corn ear; left, cross-bred ear; center and below, corn from selected kernels of ear on left

tions and then crossed with a yellow native field corn to improve its vigor. The F_3 generation of this hybrid is vigorous and apparently adapted to the soil and climate of the island.

REPORT OF THE AGRICULTURIST

By H. C. HENRICKSEN

PINEAPPLE INVESTIGATIONS

Pineapple-production investigations were begun in 1922, but received little attention because of the demands made upon the agriculturist's time by other work which had to be finished at once. In

1923, a series of pot culture experiments was started to supplement work in the field, and in 1924 a systematic study was made of various soil, fertilizer, and cultural problems having an important bearing on the pineapple industry in Porto Rico.

SOILS

Pineapple plants on certain areas outwardly manifest the unsuitability of the soil in which they are growing in a lack of uniformity in size and color of plants. This is always apparent a few months after planting, although it may be less so later. The unsuitable areas are not readily discernible until after planting. They usually occur in streaks or patches which are slightly lower than the surrounding areas, and when seen from an altitude of 15 feet or more appear lighter in color than these areas. Investigations are now under way to determine, if possible, in what respects these soils differ. Field results indicate a lack of organic matter in the soils, but laboratory tests show little difference between the two kinds of soil in this respect. Heavy fertilization benefits the plants on the poorer soils, but it does not completely remedy the defect; sulphur, likewise, is beneficial when the soil reacts neutrally but is not a complete remedy. Such factors as soil aeration, moisture, temperature, plant nutrient content, and chemical reaction have been used as a basis for determining the suitability of a soil for pineapples before planting, and the work has progressed sufficiently to permit drawing conclusions in the near future. The problem of making an unsuitable soil suitable is being solved by noting the effect of drainage, subsoiling, and the application of organic matter and various inorganic elements on the crop. The results would seem to indicate that subsoiling, in which the soil is brought from a depth of 18 or more inches to the surface, usually benefits the plant. The application of organic matter, such as manure, straw, or muck, has been beneficial in all cases. Sulphur can be recommended for use on a soil containing little limestone, but not where coral sand is the predominating constituent.

FERTILIZERS

Results of experiments in the field and with plants grown in water and sand cultures indicate that no fertilizers are needed during the first four to eight weeks after planting. After that time nitrogen and potash in large quantities are needed, as is shown by the difference in growth of plants receiving these elements in varying quantities. Phosphorus, on the other hand, does not seem to be of so much importance. The most suitable form of nitrogen was also investigated for the reason that growers have found sulphate of ammonia desirable, and nitrate of soda undesirable, for the pineapple plant. This has led to the erroneous belief that the pineapple prefers nitrogen in form of ammonia. Water-culture tests at the station show that the pineapple plant removes no ammonia from the solutions, but readily absorbs other forms of nitrogen, especially potassium nitrate. Results of studies, made to learn why dried blood and cottonseed meal are frequently ineffectual as fertilizers, showed no failures due to a lack of nitrification. Nitrates may be present, but the plants do not thrive as they do with sulphate of ammonia. Sulphur, when used in combination with dried blood, apparently reme-

dies the defect, which would seem to indicate among other things that soil acidity is a limiting factor. This, however, has yet to be determined.

REPORT OF THE PLANT PATHOLOGIST

By C. M. Tucker

COCONUT BUD ROT

In September, 1923, investigations were undertaken to determine the organism causing coconut bud rot, as well as the factors contributing to its dissemination, virulence, and incubation period, and

Fig. 13.—Early indication of coconut bud rot

the practicability of eradicating diseased palms as a means of control. A survey of the western coast of the island, from Mayaguez to Rincon, revealed about 700 cases of bud rot. Palms were attacked in all stages of growth, those in sheltered location proving the most susceptible to the disease. Infection occurs most frequently during the rainy season.

The first symptom of bud rot is the death of the young emerging leaf, followed by other young leaves. (Fig. 13.) These are soon broken over by the wind and hang, tips downward, finally falling from the central column, leaving, surrounding the apex of the trunk, a fringe of healthy, nearly horizontal green leaves which gradually fall away until defoliation is complete. (Fig. 14.) Examination of

leaves that are removed with the petioles from the trunk usually discloses the presence of a dark-brown decayed spot near the base of one of the inner leaves. (Fig. 15.) Experiments have shown that infection may occur near the base of the leaf and spread through the intervening sheaths, increasing in activity as the tissue encountered becomes soft and watery; or it may spread from the youngest leaves to the bud and spongy generative tissue beneath, converting both into a soft, watery, malodorous mass.

The earliest attempts to isolate the causal organism gave nearly pure cultures of a bacterium closely resembling *Bacillus coli*. Experiments in which the bud was inoculated with cultures of the

FIG. 14.—Coconut tree in advanced stage of bud rot

organism resulted in the emergence, six weeks later, of diseased leaves which were not typical of field cases of bud rot. Several of the young leaves were badly spotted and deformed, but later leaves were healthy and normal. Check trees, wounded as for inoculation but not inoculated, produced the same type of apparently diseased leaves, after which normal leaf production was resumed.

In February, 1924, a species of Phytophthora was isolated from a palm in the earliest observable stage of bud rot. The fungus was grown in pure culture and used for inoculating healthy palms. Typical cases of bud rot followed inoculation of both wounded and unwounded palms. The fungus is probably of the *P. faberi* group, no oospores having been observed. The conidiospores have an aver-

age length of 50.4 microns and an average diameter of 30.23 microns, corresponding closely to measurements of *P. faberi*. The chlamydospores have an average diameter of 32.96 microns, and are considerably smaller than those of *P. faberi*, corresponding more closely to the chlamydospores of *P. palmivora* as described by Butler.

Forty-two diseased palms were cut and burned in a grove in the Peña Cortada district, Mayaguez, in November, 1924, to determine the possibility of eradicating the disease in a given section by destroying the sources of infection. Six new cases appeared within the next six months, five being in a group of closely planted young trees that were sheltered by older palms and by houses. Each case occurred within 30 feet of the spot occupied by one of the 42 diseased

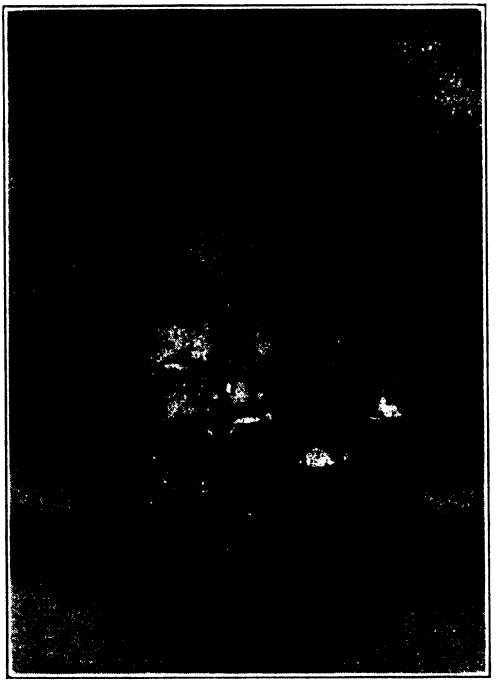

FIG. 15.—But-rot infected coconut tree. Leaf bases removed to show point of attack

palms. The trees were cut and the buds burned. No new cases of infection were apparent four months later.

A ROOT DISEASE OF VANILLA

A Fusarium has been repeatedly isolated from diseased vanilla roots. Twenty pots were filled with soil from a vanilla planting where the plants were killed by the disease two years ago. Half of the pots were autoclaved and all were planted with vanilla cuttings. Those in the autoclaved soil made a healthy growth, whereas those in the unsterilized soil failed to start, the roots being attacked and killed as soon as they appeared. Experiments using a corn-meal culture of the fungus to inoculate cuttings growing in coconut fiber

resulted in the infection of 50 per cent of the plants. Normally the disease appears in plantings about the fourth year, the accumulating acid from decaying organic matter probably creating favorable conditions for its development. An experiment was started with 200 plants to determine the efficiency of liming in neutralizing the acid and preventing the growth of the fungus in the soil. Growers have been advised to burn infected plants in situ, since the fungus spores may be disseminated from the diseased aerial roots.

LEAF-SPOTTING FUNGI

Morphological studies are being made of leaf-spotting fungi (*Cercospora* and *Helminthosporium* spp.). Thirty-five species of the fungi have been examined, and drawings and biometric measurements made of the conidia and conidiospores, and descriptions written. The *Helminthosporium* spp. are being grown in cultures. Several new features have been discovered.

SCAB-RESISTANT GRAPEFRUIT

The progeny of Duncan, a commercially valuable variety, crossed with Triumph, a relatively scab-resistant variety, has as yet produced no fruit. Seedlings producing fruit of commercial value will be grafted on rough lemon stock in a location where the scab is especially prevalent to determine their disease resistance.

BANANA WILT

A planting of Chamaluco bananas, selected for resistance to the banana-wilt organism (*Fusarium cubense*), failed to fruit this year. Although the plants have been limed and fertilized, they invariably succumb to the disease before blossoming. The planting will be destroyed and the infected area devoted to varieties which are thought to be resistant to wilt.

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PORTO RICO AGRICULTURAL EXPERIMENT STATION
MAYAGUEZ, P. R.
Under the supervision of the
UNITED STATES DEPARTMENT OF AGRICULTURE

REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION

1925

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PORTO RICO AGRICULTURAL EXPERIMENT STATION, MAYAGUEZ

[Under the supervision of the Office of Experiment Stations, United States Department of Agriculture]

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[1] Transferred to Bureau of Animal Industry, United States Department of Agriculture, June 8, 1926.

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Washington, D. C. April, 1927

REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION, 1925

CONTENTS

REPORT OF THE DIRECTOR

By D. W. May

Agricultural production in Porto Rico showed an increase during the fiscal year 1925. The production of sugar cane, the leading crop, was the largest in the history of the country, notwithstanding the fact that the price of sugar was less than since 1914. Coffee brought good prices, and the fruit industry prospered. Increased production is attributed to employing better fertilization and methods of cultivation, practicing rational systems of rotation, growing improved varieties of economic plants, and introducing purebred livestock.

LIVESTOCK

The station since its inception has strongly stressed the need of importing improved breeding stock into Porto Rico, and has benefited the local industry by lending purebred sires for breeding, by assisting farmers to procure better stock from the States, and by distributing surplus station-bred animals at a nominal price to all parts of the island. So far as known, the station introduced the first registered horses, cattle, and pigs into the country. The ever-changing economic conditions have brought about a difference in the use of certain of the domestic animals. Horses, once saddle-bred or used to draw light vehicles, are being replaced by the automobile. Cattle, used in the early days to cultivate the soil and for heavy transportation, are rapidly giving way to the tractor in the field and to the auto-truck on the highway.

The native cattle are good foundation stock. They are large-boned, excellent work animals, and their upkeep is small. They are slow to mature, however, are poor milkers, of poor beef form, and show a lack of selection in breeding. The station, by crossing native cows with purebred sires, has developed a herd carrying fifteen-sixteenths Guernsey blood. A few purebred heifers have been added to the herd. Each succeeding generation has steadily increased in milk

production. Some of the three-quarters bred cows have yielded over 5,000 pounds of milk annually, and the purebreds with first calves an average of 4,500 pounds annually. The station has amply demonstrated that early development, improved conformation, and increased milk production can be brought about by using purebred sires, and that, given the good care to which they are accustomed in the North, purebred animals can be developed in Porto Rico. Under the present conditions, however, the breeder is advised to build up his herd by introducing purebred sires of the breed he fancies most and to confine his efforts to breeding either for beef production or for dairy qualities.

DAIRYING

Profits from raising cattle for dairy purposes give promise of exceeding those obtained from any other branch of animal industry. Demands for beef and dairy products continue to increase. The

FIG. 1.—Cheddar, Swiss, and Edam cheese made at the Porto Rico Experiment Station

imports of the latter are among the largest of the island, and were valued at $2,039,221 during the year. Probably the greatest demand of the present is for fresh milk, which brings the highest returns of the dairy products. Although dairying is on the increase, in time it will be impossible to market all the milk that is locally produced. A surplus of the commodity can best be used in the form of butter and cheese. The station, anticipating this situation, has made some experiments to determine what factors influence butter and cheese making under tropical conditions. Results of the experiments so far indicate that sweet cream butter and several kinds of cheese can easily be made without the use of ice, and that a surplus of milk can be converted into salable products for local consumption. Cheddar, Swiss, Stilton, and Roquefort cheese have been made at the station (fig. 1), the proper organisms having been isolated from imported

Stilton and Roquefort cheeses. Powdered rennet, which can be readily gauged to any quantity of milk, has given the best results when used with milk which was carried over night and mixed with that obtained the next morning.

REFORESTING

Mahogany (*Swietenia mahagoni*) (fig. 2), horsetail tree or Australian ironwood (*Casuarina equisetifolia*), and Maria (*Calophyllum calaba*) are making the best growth of 60 acres of forest trees planted in 1924 by the station.

A number of economic questions enter into the problem of reforesting land in Porto Rico. Where the trees have been cut from the land the soil is deficient in nitrogen. To make these lands an agricultural success they should be planted with a leguminous tree or

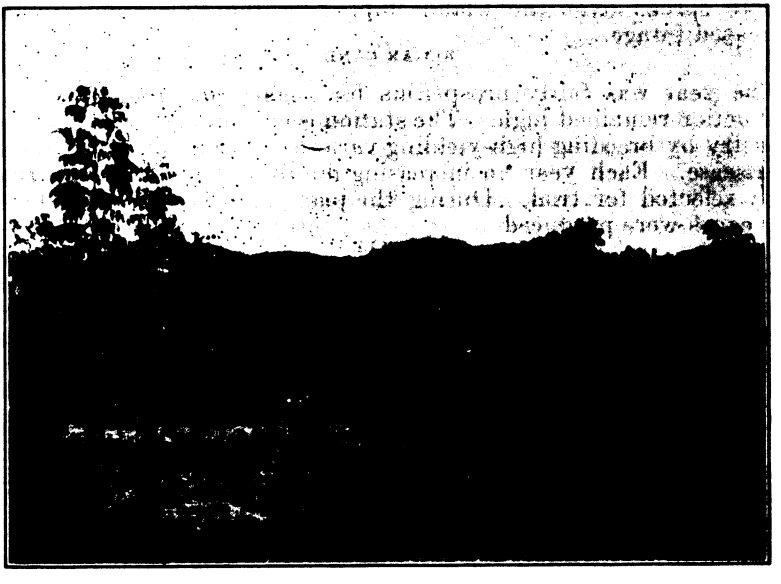

FIG. 2.—One-year-old mahogany trees at the Porto Rico Experiment Station

with a legume as a catch crop. Tree planting should be done with judgment and a look into future needs. Forest trees make rather slow growth, and if the farmer of small means would derive some return from his land while soil improvement is going on he should plant early-maturing trees of economic importance. This planting may consist of fruit trees, such as citrus, coffee, or cacao, and if others, legumes as a nurse crop. Forest trees should be of a type not readily destroyed by livestock if the land is to be utilized for grazing while the trees are in process of development.

FORAGE CROPS

The areas planted with elephant grass (*Pennisetum purpureum*) and Guatemala grass (*Tripsacum laxum*) were extended throughout the island. The grasses vary in yields under different methods of culture. The Guatemalan variety seems to be the more highly favored by ranchmen. It makes quicker growth than does elephant

grass, is more succulent, and is consumed in greater percentage per plant by stock. A well-balanced green ration may be obtained by planting velvet beans in the stubble remaining after each crop of Guatemala grass is cut. Uba cane is also highly recommended as stock feed and perhaps can be more economically converted into milk than into sugar when the price of the latter is low and transportation charges are high.

Clovers, including white, red, sapling, mammoth, alsike, bur, crimson, and peavine varieties, alfalfa, and hairy vetch grown from seed imported from the North were not a success at the station even when inoculated with the proper nodule-forming bacteria. Further trials may render these crops adaptable to island conditions. Lespedeza and Bokhara, or sweet clover, promise the greatest success for Porto Rico. When these varieties are planted in inoculated soil they bid fair to spread over the island, improving the soils and providing increased forage.

SUGAR CANE

The year was fairly prosperous for sugar cane, but the cost of production remained high. The station is continuing to aid the sugar industry by breeding high-yielding varieties of cane proving immune to disease. Each year an increasing number of seedlings are rigorously selected for trial. During the past season over 100,000 seedling canes were produced.

COFFEE

Coffee brought an increased price during the year, and growers devoted more attention than formerly to the cultivation of the trees and planted varieties which were introduced and disseminated by the station. The repeated efforts of the station to induce growers to fertilize the crop are beginning to bear fruit. Low-yielding varieties should be replaced with high-yielding, disease-resistant varieties, the seed of which may be obtained from the station for the asking. Planters are also urged to prepare thoroughly and cultivate the soils intended for coffee, to change the variety of trees used to shade the crop, and to live on their plantations, when possible, in order that they may give the industry the full attention it requires.

MARKETING AGRICULTURAL PRODUCTS

Knowing how to market a crop is probably one of the most important requirements of modern agriculture. Success depends primarily on the kind of preparation given the crop or on the method followed for preserving the manufactured product. Perishable food products spoil very quickly in the Tropics and may be either greatly improved or rendered useless by certain processes of fermentation. Many otherwise waste products can be saved by drying and canning. Tons of overripe, unshapely grapefruit, for example, are now profitably canned and marketed at leisure on the mainland.

The station has worked assiduously for 20 years in introducing, growing, and disseminating the best varieties of mango from different parts of the world, and is now endeavoring to provide a profitable outlet for surplus quantities which are prevented by quarantine regulations from being exported. Methods of canning have been developed as a means of utilizing the fruit and give promise of becom-

ing of commercial importance. The canned product has the consistency and appearance of the peach. Experiments in canning the avocado have not been very successful. The fruit is spoiled by cooking, absorbs too much salt when canned in brine, and is softened or dissolved, losing its character, when preserved in salad oils.

CACAO

Cacao yields fairly well in Porto Rico, but is not of the best quality. Of three varieties used in a local factory that from Venezuela ranks highest, and the varieties from Porto Rico and Santo Domingo next, in the order named. The difference in quality is probably due to the different methods used in curing. The Venezuelan variety is coated with earth at the close of the fermentation period.

Cacao beans when removed from the pod are embedded in a white slimy pulp which readily ferments. Fermentation causes the pulp to break down, releasing the seeds, and is accompanied by characteristic odors, especially of acetic acid. Fermentation, however, does not favorably affect the development of aroma within the bean. The aroma is developed by the action of flavor-forming enzymes in the bean, and an excessive production of acetic acid not only inhibits the action of the enzymes but also lowers the quality, especially the flavor, of the beans.

Results of experiments made with various substances as coatings for the beans at the end of the fermentation period showed a favorable influence on the quality of the resulting product. Clay and natural lime gave the best results of the several applications tried. Improvement in quality of beans was due partly to the neutralization and elimination of the acids forming in the slimy pulp by fermentation and partly to coating or sealing the beans, which then retain their aroma.

REPORT OF THE ASSISTANT CHEMIST

By J. O. Carrero

MANAGEMENT OF CANE SOILS

Further studies were made of nitrogen utilization by cane soils. The second-plant cane crop, grown under treatments with nitrogen, legumes, and lime, was cut early in the year and crop yields of the different plats were recorded. Four stools in different parts of each plat were preserved to compare the proportion of trash, leaves, and tops with clean cane. Trash, leaves, and tops corresponding with the stools were preserved for analysis to learn the quantity of nutrients they extracted from the soil and of loss when they were burned. Data were obtained on all the fertilizing elements extracted by the crop, the quantity returned to the soil in the trash, and the quantity lost when the cane was carted away.

Samples of soils under treatment and from a check plat were taken to learn what fertilizing elements they contained and their acidity and lime requirements. Changes taking place in the various plats during treatment and the effect of each treatment on the soil were readily determined because the original composition of the plats was known.

The trash, leaves, and tops from the harvested plant crop were used as a mulch on sections of the field where mulching was required,

and quickly burned on other sections where a first ratoon crop was to be grown. No potash or phosphoric acid was applied to the crop. Nitrogen, the only fertilizer used, was applied in the form of ammonium sulphate to one section and as sodium nitrate to another. A third section was left to serve as a check. Table 1 gives the results of the test.

TABLE 1.—*Comparative yield in tons of second-plant cane plats under different treatments*

Plat series	Trash burned			Trash plowed under		
	No legume	Legume plowed under	No legume	Legume plowed under	No legume	Legume plowed under
Limed:	*Plat 1*	*Plat 2*	*Plat 3*	*Plat 4*	*Plat 5*	*Plat 6*
A	32.864	36.832	30.200	32.430	29.600	[1]33.180
C	48.520	49.320	49.683	51.861	44.565	[2]45.860
E	47.108	47.840	47.311	48.860	41.620	43.330
Unlimed:						
B	33.100	36.960	35.000	38.000	33.810	[1]39.277
D	48.110	50.224	48.710	51.600	44.180	[2]46.000
F	46.053	48.000	46.416	47.200	42.300	[3]44.280

[1] No nitrogen. [2] Nitrogen as $NaNO_3$. [3] Nitrogen as $(NH_4)_2SO_4$.

In addition to the differences resulting from the various treatments given the plats, another and perhaps the main difference resulted from the use made of the crop residues and from the agency of a green-manure crop. To learn something of the behavior of cane leaves and trash when buried in the ground, the dry, finely ground cane leaves that were saved for chemical analysis were mixed in different proportions with 200 grams of a red clay soil, chosen because of its low content of nitrogen and phosphorus. The test was carried on for 65 days, the different treatments being examined for ammonia and nitrate nitrogen every sixth day for the first 30 days and every tenth day for the remainder of the period. The test was repeated under similar conditions except that a river loam which was fairly rich in lime was substituted for the red clay soil. The checks in these tests failed to give closely concordant results except in a few instances where the smallest quantities of leaves were used.

EFFECT OF SULPHUR AND SULPHUR COMPOUNDS ON SOILS

In continuation of experiments made to determine the value of sulphur as a fertilizer for Porto Rican soils two crops were raised. As was previously the case, the pots which were treated with sulphur, whether used as sulphur or as gypsum, showed slight increase in plant growth over pots receiving no sulphur. The soil under treatment is deficient in phosphorus. Sulphur when used alone gave only insignificant gains as compared with nontreatment, but when used as sulphates showed considerable gain over both nontreated and sulphur-treated pots. Significant gains resulted only when the sulphur was accompanied by phosphorus, but the increase was smaller than when phosphorus alone was used.

ANALYTICAL WORK

During the year analyses were made of samples of the various field crops under experiment, cane leaves, trash, tops, and bagasse, and the juice of varieties of cane from 36 plats under observation. Soil samples from the various plats under treatment were analyzed to determine what changes took place in composition and texture as the result of treatment. Analyses were also made of 460 samples of cane juice as well as a few samples of guanos and soils that were sent to the station.

REPORT OF THE AGRICULTURIST

By H. C. HENRICKSEN

PINEAPPLE INVESTIGATIONS

Pineapple production in Porto Rico has fluctuated within wide limits since commercial cultivation of the crop began. In 1910 some 277,000 boxes of fruit, valued at $555,000, were exported. Production increased until 1915, when 552,000 boxes, valued at $1,723,000, were exported, and decreased during the next four years, only 116,000 boxes being exported in 1919 and 140,000 in 1920. Production again slowly increased, and in 1925 some 342,547 boxes, valued at $1,046,000, were exported. The fluctuation was partly due to a lack of knowing how to solve various problems connected with the industry. Fields did not continue to produce satisfactorily and new soils failed to produce as well as they were expected to; fertilizers did not always give the desired results, and the crop itself seemed to be deteriorating. Crop deterioration, however, was partly overcome by introducing several million slips from Cuba in 1921, 1922, and 1923, and by planting in suitable soils in the mountain districts. To learn the answers to other problems, including how to produce slips equally as good as those from Cuba, obtain maximum yields from using fertilizers, and determine the suitability of soils before planting, the station began a series of pineapple-production investigations, the results of which have proved to be of immediate practical value to local planters.[1]

SOIL MOISTURE

Results of investigations show that growing plants of the Red Spanish variety, 6 to 10 months old, transpire on the average 3 per cent of their weight every 24 hours. At this age each plant weighs approximately 1 kilogram, and, therefore, transpires 20 to 40 grams each 24 hours.

A method for determining the capability of a soil to deliver 20 to 40 grams of water to a well-rooted plant was developed by using homemade soil points. These were cylinders made from brick clay. After being well baked they measured 1 inch in diameter and slightly more than 5 inches in length, and after the ends were shellacked the cylinders had an absorbing surface of 16 square inches. Their average weight was 138 grams when dry and 164 grams when saturated, which was an increase in weight of about 19 per cent. Several cylinders were weighed and then buried in the soil about 6 inches deep

[1] The results have been published for general dissemination in mimeographed numbers of Agricultural Notes, available copies of which may be had upon application to the agriculturist.

and a foot apart. After 24 hours they were taken up, brushed, and again weighed. The gain in weight by all the cylinders divided by the number used showed the average quantity of moisture absorbed from the soil by each cylinder. The quantity of moisture absorbed in a certain time depends upon moisture content, which varies in different soils. A soil delivering an average of 5 grams of water each 24 hours to each cylinder can be depended upon to supply 20 to 40 grams to a well-rooted pineapple plant in the same length of time. It is concluded, therefore, that pineapple plants are not suffering from drought when grown on soils in which soil points continue to absorb 5 grams of moisture every 24 hours. By the use of soil points it was found that an excess moisture content was a problem more frequently than a deficiency.

SOIL AERATION

Many seemingly adverse conditions in pineapple fields were found to be the result of poor soil aeration. Lack of aeration may be caused by high water content, but frequently it is due to the physical composition of the soil and the state of its colloidal matter.

The state of the c lloidal matter in the soil may be determined by stirring a sample of soil with water and allowing it to stand for about 30 minutes. If the colloidal matter is in a state of perfect flocculation the soil will settle in that time, leaving the supernatant solution clear. If the colloidal matter is not in a state of perfect flocculation the soil will be a longer time in settling. The length of time required for settling may be used as a rough measure to determine the suitability of any soil for pineapple growing. In general, the more rapidly the soil settles the more suitable it is for pineapples, provided that the reaction of the soil solution is distinctly acid. The problem of aeration is serious at times for planters using paper mulch. Mulching has been used on a limited scale during the last two years and has been found to benefit soils that dry out during prolonged periods of drought. On the other hand, the results of the last year's investigations show that mulching is detrimental on the same kind of soils or on any soils retaining water nearly to the limit of saturation during prolonged rainy periods. The damage caused has been ascertained to be due directly to lack of aeration.

SOIL REACTION

Results of the investigations also show that a soil yielding a solution with a hydrogen-ion potentiality of 7 or over is not suitable for pineapple growing. A soil may prove to be suitable when the pH value is well toward 6 and the colloidal matter flocculates well; on the other hand, soils giving a pH value of 6 and poor flocculation are not likely to prove suitable. A soil may be said to be suitable when the pH value is much below 6 and the solution settles quickly. At least this holds true for all the Porto Rican soils thus far examined.

IMPROVING UNSUITABLE SOILS

Results of the last year's investigations show that (1) the suitability of a soil for pineapple growing may now be determined before planting; (2) it is possible to learn whether an unsuitable soil can be made

suitable, and if so, whether economically; and (3) if a rational system of rotation is practiced, a field can be made to produce more than two crops of pineapples.

An area which is not sufficiently aerated, due to an overabundance of moisture, should be thoroughly drained, when possible. Soils containing an overabundance of fine soil particles are benefited by treating with coarse, organic matter. Muck at the rate of 10 tons per acre is giving excellent results on a sandy soil where the particles are too fine for perfect aeration. Muck is, of course, not always available, but several kinds of plants can be plowed under instead. *Crotalaria juncea* is suitable for growing on sandy soils, and *C. striata*, *Tephrosia candida*, and pigeon peas (*Cajanus indica*) also give good results. Even *Urena lobata*, which grows wild on most sandy soils, may be used to good advantage, provided it makes a close stand.

Sulphur is the best treatment for unsuitability resulting from a high pH value and deflocculation of the colloidal matter. Five hundred pounds per acre should be sufficient, but a ton or more may be needed if the soil has a high lime (calcium carbonate) content.

To test the soil for carbonates, stir a sample with water and eliminate the lighter particles. Spread the remaining soil on a plate and add a few drops of hydrochloric acid. If much effervescence takes place the soil should not be used for pineapple growing, and can not profitably be made suitable by an application of sulphur. The colloidal matter in most subsoils is in a state of flocculation, and subsoiling may be beneficial when flocculation of the surface soil is needed. The benefit to be derived from subsoiling, however, is contingent upon the state of the colloidal matter and the degree of acidity of the surface soil and the subsoil. Five per cent of the subsoil may be sufficient to bring to the surface, but the approximate quantity necessary can be determined by mixing the surface soil and the subsoil in various proportions, stirring the mixtures in water, and determining the rate of settling.

Puddling, due to cultivating when the soil is too wet, may be remedied by working the area when the moisture content is most favorable for producing crumb structure, followed by planting with cover crops. Continuously cropping a soil with pineapple plants may result in an unsuitable soil. The local practice is to harvest two crops from the field before replanting. A soil having good crumb structure and a fairly high content of organic matter may be successively replanted three or four times, but better results will be had if the pineapple crop is rotated with sugar cane or with some cover crop.

SULPHUR

During the last three years sulphur has been used in varying quantities on soils ranging from light sand to heavy clay. Results of an experiment, started in 1922 to determine the degree of soil acidity produced by sulphur and the effect on the pineapple plant, showed that applications of 1,000 to 2,000 pounds per acre changed the pH value from 6 or 6.2 to 3.6 in 2 months, and at the end of 4 months to 3. After 6 months the reaction gradually changed and at the end of 12 months it was again between 6 and 6.2. A comparison of the treated and check plats showed that sulphur was beneficial to the pineapple plant. Weed growth was very much depressed by sul-

phur, the plat receiving treatment at the rate of 2,000 pounds per acre producing none. Mole crickets were not to be found as long as the pH value was between 3 and 4, although crickets and weeds were abundant in the check plats. The pH value changed to 2.8 in plats receiving sulphur at the rate of more than 2,000 pounds per acre, and to 2 at the end of 2 months in one plat of poor sandy soil receiving sulphur at the rate of 5,000 pounds per acre. The reaction in all cases returned to 6 to 6.2 before the end of 12 months. Applications of sulphur above 2,000 pounds per acre depressed the growth of pineapple plants according to the character of the soil. In one plat where the soil was a heavy loam containing much organic matter sulphur applied at the rate of 6,000 pounds per acre did no more damage to the crop than was done on another plat of sandy soil treated at the rate of 4,000 pounds per acre.

The effect of sulphur on soil nematodes was determined by growing potted dahlias in heavily infested soil instead of the pineapple plant which is not a good indicator, although it may be damaged by the pest. The results showed that dahlias can be grown on heavily infested soil so long as the pH value remains well below 5. This would seem to indicate that pineapples growing on nematode-infested soil might be benefited by sulphur applied at the rate of 1,000 pounds per acre.

FERTILIZING

The problems connected with pineapple fertilizing are many and complicated. Questions dealing with forms and combinations of nitrogen, potassium, and phosphorus best suited to the growing crop and proper time and rate of application have been partly answered. Ammonium sulphate has proved to be a suitable form of nitrogen on all soils under all conditions. Organic forms may be used when the soil is fairly acid and the colloidal matter is flocculated. With deflocculation of the colloidal matter and a pH value above 6, organic ammoniates, such as cottonseed meal, dried blood, and tankage, are not suitable, at least not until the adverse conditions have been remedied.

Sodium nitrate and calcium nitrate may be used on fairly acid soils containing large quantities of organic matter; otherwise, nitrates should not be used. In some of the latest but uncompleted experiments potassium nitrate has proved to be unsuitable for plant growth, even on acid soils having a high humus content. Phosphorus in the forms of ground steamed bonemeal, and acid phosphate has not given definite results when applied to growing plants.

Results of tests with soil samples from many fields on which pineapples are growing showed that nitrogen and potash were needed in large quantities. The actual quantities required at any time in any soil are, of course, not readily determinable by chemical analysis. Plats failing to yield 50 milligrams of water-soluble nitrogen per kilogram of soil responded to an application of nitrogenous fertilizer. Likewise, plants failed to attain maximum growth on plats the potassium content of which was not upwards of 100 milligrams per kilogram of soil. A 1 per cent citric-acid solution was used for extraction. A method for determining the weight of the soil, using these figures, was worked out. To learn whether the use of large quantities of fertilizer would pay, nitrogen and potassium each in quantities of 30 to 40 milligrams per kilogram of soil were applied to one group of plats;

the quantities were doubled on a second group and tripled on a third. Results as measured by plant growth were very much in favor of the heaviest application.

In another experiment a plat was fertilized every 12 weeks with a mixture carrying 100 milligrams of nitrogen and 150 milligrams of potassium per kilogram of soil. A second plat was fertilized every 6 weeks with the same mixture, using half the quantities applied in the first instance. Results were again in favor of the heavier application at longer intervals. The results correspond with those of pot experiments and show that the pineapple plant does not attain maximum growth unless it is grown on a soil which is high in nitrogen and potash. However, considerable loss may result from an effort to keep the elements high, as is illustrated, for example, in the last-mentioned experiment, in which one application was made in the rainy season and was followed by more than 3 inches of rain during the next 24 hours. The soil was sandy and leached out very heavily, results of tests made 24 hours later showing that only 27 milligrams of nitrogen and 38 milligrams of potassium per kilogram of soil remained. Under similar circumstances the applications evidently should be smaller and more frequent. The results show the advisability of making soil tests to learn whether leaching has occurred, in which case another application should be made immediately to prevent the plants from starving.

REPORT OF THE HORTICULTURIST

By T. B. McClelland

EFFECT OF VARIATION IN DAY LENGTH ON GROWTH OF CERTAIN PLANTS

Studies of photoperiodism were confined to crop plants of local economic importance. Plantings of beans (three varieties) and sweet potatoes (two varieties) were made at four-week intervals. One group is kept under normal light conditions; in the second the illumination is supplemented by electric light throughout the year so as to approximate the length of day for June in this latitude; and for the third group the light exposure is kept at the December day lengths. Most of the plants are left in the group in which they started, but some are shifted from one group to another. As was the case in previous tests, both growth and blossoming of some species are affected to a pronounced degree by the limited range in day length for this latitude. Other species, however, are affected to a lesser degree. Many experiments will have to be made with the latter before definite conclusions can be drawn. Measurements of growth, date of blossoming, and date and weight of crop are being recorded for the plants under test.

COFFEE

Fertilizer experiments with coffee continue to show that production is strongly influenced by the kind of fertilizer applied. In a long-term cooperative experiment comparing both complete fertilizers and nitrogen alone the former showed pronounced superiority over the latter in regard both to the crop harvested within the year and that on the trees at present.

Records have been compiled showing the yields for eight years of another group of coffee trees grown on 40 plats, including checks, those receiving 1 element only and those treated with 2 or 3 elements in combination. Production per tree for the latest crop averaged 1½ pounds of dried coffee beans after the removal of the parchment. The record of production for this crop shows that potash, particularly when used in addition to nitrogen, was effective in increasing yield. In this crop 11 plats yielded better than the best check. These agree in one particular only. All received potash, 4 received nitrogen only in addition to potash, 1 received phosphoric acid in addition to potash, and 3 received both nitrogen and phosphoric acid in addition to potash. In the harvests for each of the eight years the group of plats receiving complete fertilizer and the group from which phosphoric acid had been omitted outyielded the unfertilized plats. The group receiving the potash alone outyielded the check for seven of the eight years. Nitrogen in heavy applications without potash very adversely affected fruiting, whereas the same quantity used in conjunction with potash proved beneficial rather than injurious. The appearance of the trees as well as their production was affected by the treatments, the plat receiving nitrogen alone in heavy applications producing only sparse foliage and poor growth in contrast with the luxuriant foliage and growth made by the plats receiving nitrogen and potash in combination. The highest yield for the eight-year period was made by the plat receiving nitrogen and potash at the heaviest rate, but no phosphoric acid. The last two yields from the plat were very high, averaging 2 pounds 15 ounces and 2 pounds 13 ounces, respectively, per tree per annum of dried coffee beans with the parchment removed.

In 1923 three series of forty 5-gallon containers were each filled with heavy clay, river loam, and beach sand to compare the effects of ammonium sulphate and sodium nitrate. Two seedlings were set in a container. Each soil group of 40 cans comprised 10 receiving 8 grams of ammonium sulphate semiannually; 20 receiving the same quantity of nitrogen in the form of sodium nitrate (10 in semiannual applications of 10 grams and 10 in monthly applications of 1.7 grams); and the remaining 10 cans, which received no nitrogen. Half the cans in each division, except that receiving ammonium sulphate, were given, in the form of flowers of sulphur, semiannual applications of sulphur equal to that carried in 8 grams of ammonium sulphate. The test was terminated 18 months after making the first application. Nitrogen was insufficient to sustain the coffee trees in beach sand. The seedlings growing in the river loam became heavily infected with disease, whereas those in the heavy clay soil grew vigorously.

Of the trees grown in clay, the group receiving sodium nitrate monthly and sulphur in addition ranked first in number of leaves and in weight of both leaves and woody growth. In height there was little difference between this group and the two groups receiving ammonium sulphate and sodium nitrate, respectively, in semiannual applications plus sulphur. Considering the growth as a whole, it was found that these two latter groups tied for second place. The group receiving monthly applications of sodium nitrate but no sulphur fell below these three leading groups in weight of both leaves and woody growth and in height, but in every particular it surpassed the group receiving in all an equal quantity of sodium nitrate given in semiannual rather than in monthly applications. The two groups given

no nitrogen ranked below all others in every particular, the differences in number of leaves and weight of foliage and woody growth being pronounced. The group receiving sulphur alone failed to equal the check, though this fact is presumably without significance.

Data pertaining to coffee fertilization were submitted for publication during the year.[2]

COCONUTS

Data on coconut production from various experimental plats would seem to indicate that considerable additional work must be done before definite conclusions can be drawn regarding the effect of different fertilizers on the crop. The wide variation in yield of individual trees receiving identical treatment and grown under apparently very uniform conditions makes plat yields less significant. In one plantation where 100 trees are under observation generous semiannual applications of fertilizer, continued through three years, fail to show definite effects.

ROOT CROPS

SWEET POTATOES

Numerous sweet-potato seedlings were tested, but, failing to equal in merit the named varieties already grown, had to be discarded. Field plantings for comparative purposes were attacked by slugs and rendered worthless.

YAUTIA, DASHEEN, AND TARO

During the last two years yautias, dasheens, and taros have been under test to ascertain the effect on them of storing at normal temperature. The large corms of the Penang taro do not keep more than a few days after digging, whereas 2 to 4 ounce cormels will keep longer, approximately half of those stored being still firm and in good condition at the end of 16 weeks. Of these, half remained firm from 8 to 10 weeks longer. The dasheens showed rot amounting to 10 per cent in 8 to 16 weeks, varying with the variety, and 50 per cent in 18 to 22 weeks. The yautias showed rot amounting to 10 per cent in 6 to 18 weeks and 50 per cent in 16 to 28 weeks. Rodents and mealybugs both proved to be troublesome during the storage tests.

CROTALARIA SPP. AS COVER CROPS

On May 20 plantings of Crotalaria, including *C. juncea*, *C. striata*, *C. usaramœnsis*, *C. retzii*, *C. saltiana*, and *C. anagyroides*, were made for comparative purposes. Heights were measured at approximately 3, 4, 5, and 6 months, and the weights of the green growth estimated at 15 and 20 weeks after planting. At three months, *C. juncea*, measured 110 inches, which was then two to three times the height of the other species. In ultimate height, *C. juncea* held first place, measuring 115 inches, with *C. striata* second, 110 inches, and *C. usaramœnsis* third, 90 inches. At 15 weeks *C. juncea* held first place in weight of green growth, yielding 13.2 tons per acre, with *C. usaramœnsis* second, producing 9.9 tons. At 20 weeks two species exceeded this production, *C. usaramœnsis* weighing 14.9 tons and *C. striata* 14.2 tons per acre, whereas *C. juncea*, past its prime, with little foliage remaining and blossoming about over, dropped to 12.6 tons. At 6 months *C. juncea*

[2] Porto Rico Sta. Bul. 31, Experiments in Coffee Fertilization in Porto Rico, copies of which may be had by addressing the director of the station.

had matured its seeds and died, whereas *C. striata*, *C. saltiana*, and *C. usaramœnsis* were still in full leaf. The latter at 9 months was the best in the field, well leafed and still flowering. *C. anagyroides* was too susceptible to thrip injury to be of promise for local propagation.

Since the Crotalarias are valuable cover crops, furnish mulching and temporary shade, and show such a wide range in growth, a knowledge of their specific differences should be acquired to enable planters to determine the species best serving individual needs.

MISCELLANEOUS FRUITS

Additional varieties of mango came into bearing during the year. Of these, the fruits of Gola and Peter's No. 1 are sweet, but insipid, and of inferior quality to many other imported varieties. Faizan has proved to be identical with Sufaida. Enuria is of good quality

FIG. 3.—Mangosteens (*Garcinia mangostana*). The fruits vary from a little over 1 to nearly 3 ounces in weight

and resembles Cambodiana in flavor, although it has certain distinctly different characteristics.

A number of exotic fruits came into production, including the mangosteen (*Garcinia mangostana*), of which two trees were imported about 1903. (Fig. 3.) These produced a few fruits in 1920 and are now bearing fairly well. The fruits have ripened during August and September and again during November and December, and vary in weight from a little more than 1 to nearly 5 ounces, with an average of 3½ ounces. The flavor resembles that of the grape and is refreshing and pleasing, although without decided character.

Euphoria didyma (*Nephelium glabrum*, S. P. I. No. 21245), a relative of the litchi, and introduced into Porto Rico by the station in 1908, fruited heavily during the summer. The fruit is small, deli-

cious, very sweet, and suggestive of maple sirup in flavor. The tree is frequently visited by bees and may prove to be a valuable source for honey production. Extensive distributions will be made of the variety.

The Florida Marvel blackberry has grown vigorously, but fruited very sparingly.

A mabolo tree (*Diospyros discolor*) is producing seedless fruit of good quality.

The Guinea oil palm (*Elaeis guineensis*, S. P. I. No. 36973), introduced by the station in 1916, fruited for the first time in the spring of 1925. (Fig. 4).

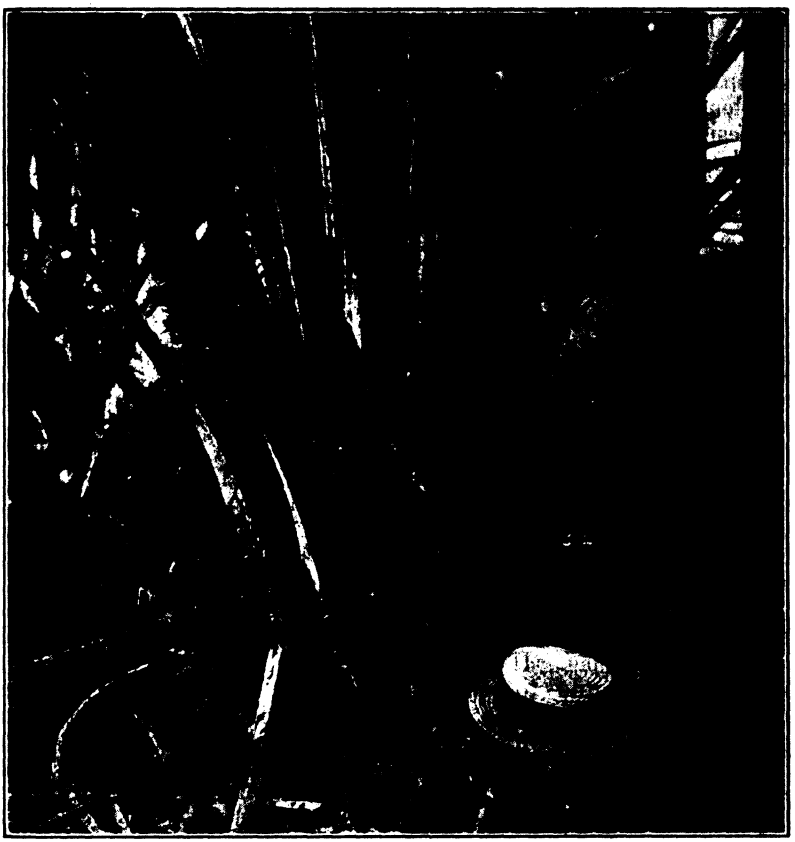

FIG. 4.—Guinea oil palm (*Elaeis guineensis*) in fruit

REPORT OF THE PLANT BREEDER

By R. L. DAVIS, and JOSÉ A. SALDAÑA, *Assistant*

FIELD CORN

Seedling characters of field corn were again studied, and high-yielding strains were isolated for use in developing selfed lines and continuing those already developed.

The serious effect of drought on seedlings was demonstrated in an August, 1924, harvest of 70 ear-to-row selections. Forty-four ear rows

that were severely wilted by drought when 11 days old produced an average of only 17.7 bushels of shelled corn per acre, as compared with 11 mediumly damaged rows which produced an average of 38.5 bushels, and 15 resistant rows, which yielded an average of 43.6 bushels.

A study for elimination purposes was made to determine the relation of leaf color of corn seedlings to their ability to resist drought. Seedlings from 116 ears of corn in germination flats when 8 days old were graded in leaf color according to Ridgeway's color standards. Only 13 of the seedlings proved to be drought resistant, enduring water starvation for two to three days longer than the others. Over one-fourth of the cultures having parrot-green leaves were resistant; in fact, 9 of the 13 resistant cultures had parrot-green leaves. Only 4 of 57 cultures having calliste or calliste-to-parrot-green leaves were resistant, and 2 of these may be ruled out because of their relatively small leaf area. None of the dark or grass-to-cossack-green cultures were resistant. These data indicate that corn seedlings with medium green leaves are more resistant to drought than are those having light or dark-green leaves.

In an effort to obtain high-yielding strains, ears were collected from Lajas, Peñuelas, Jayuya, Lares, Barranquitas, Toa Alta, Coamo, Aibonito, Cidra, Morovis, and San Germán. At present the corn from Peñuelas and Barranquitas seems to contain the breeding material giving the most promise. The Barranquitas corn is of interest because approximately 40 per cent of the plants bear two ears, whereas ordinarily, less than five per cent of the corn grown in Porto Rico develops more than one ear. The Peñuelas corn contains high-yielding elements.

In the yields for the fall crop of 1924 seed of 21 ears from Peñuelas averaged 25.7 bushels per acre; 11 from Lares, 21.3 bushels; 19 from Jayuya, 19.7 bushels; and 22 from Lajas, 18.4 bushels. Half of the ear rows from Peñuelas corn ran between 25 and 35 bushels per acre, whereas only one-sixth to one-tenth of those from the other three districts came within this range. Second season tests were made in 1925 with ear remnants from the highest yielding ears from each district. Castillear–1, the highest yielding ear in the fall of 1924, came from Peñuelas. If an average of the two crops is considered, Castillear–1 is found to have produced 49.1 bushels, and A. C.–19, the best yielder from Lajas, 32 bushels, and R. P.–1, the best yielder from Lares, only 26.1 bushels. A two-year record is not available on Vincens Flint–2, the highest yielder from Jayuya in 1924, but an indirect comparison may be obtained from the yields of selfed lines in 1925. Five selfed lines from Castillear–1 yielded on the average 42 per cent more than 14 selfed lines from Vincens Flint–2 Furthermore, the highest yielding selfed line of the 39 tested was Castillear–1–3, a selection made from Castillear–1. Thus, in Mayaguez, corn from Peñuelas not only has given the highest average yield but also has furnished the highest yielding individual ear, which, in turn, has produced the highest yielding selfed lines.

SWEET CORN

Sweet-corn hybrids were produced by crossing the most vigorous pairs of strains in the 1924 crop, and a rigid elimination was conducted by growing native field corn in the same hills with sweet corn

and discarding all sweet corn of inferior growth. Of the 1924 selections made to obtain husk protection, strain No. 24–2–5 was a marked improvement over others and was only slightly damaged by earworms. The selections developed from sweet-corn kernels found on ears of native field corn proved to be superior to selections from hybrids resulting from crosses between native field corn and sweet corn introduced from the North. Selfed lines have been started from several of the more promising strains of pure native extraction.

SUGAR CANE

BREEDING

Field and chemical data were obtained in March, 1925, on the best 400 of 2,100 seedlings which had been set in the field in April, 1924, and many seedlings having no potential value for commercial purposes were analyzed to determine their relative value for breeding work. Seedlings containing 16.75 per cent of sucrose or over numbered 27 of 283 of the D–109 variety, 3 of 31 of the G. C.–1486 variety, and 7 of 22 of the S. C. 12/4 variety. These figures would seem to indicate that the chances of finding high sucrose seedlings are two-thirds greater in the S. C. 12/4 variety than in the other two kinds. Only the larger seedlings were tested but they represented a random sampling of each variety so far as sucrose was concerned.

Judging by the results obtained with the 1924 crop of cane seedlings, poor varieties may produce good seedlings, and vice versa. The variety E. K.–28, which is considered good, gave the poorest seedlings of any tested, all being small and sickly. Rayada, a mediocre variety, produced very poor, slow-growing seedlings, and S. C. 12/4, one of the best varieties grown in Porto Rico, bore seedlings showing inferiority to the parents in size. The seedlings of E. K.–28, Rayada, and S. C. 12/4 were grown in 10-inch clay pots and given better treatment than the D–109 seedlings, which were grown in flats. The latter, however, made the best growth. G. C.–1486, which is a mediocre variety and not so extensively propagated as D–109, produced very good seedlings, some of which excelled the parent. Only one, however, seedling MPR–50 (nursery No. 4 G.C. 1486–1), was selected for further testing.

The original stool of seedling MPR–50 in 1924 yielded 84 pounds of cane, more than did all the other varieties, except Cristallina, which gave 90 pounds per stool. The yield of sucrose was 15.95 per cent, and of purity 88.3 per cent. Assuming a 100 per cent stand 5 by 3 feet to have been obtained, the variety yielded at the rate of 121.41 tons of cane and 12.274 tons of sugar per acre. The variety seems to have early maturing qualities, since it yielded heavily at 16 months after seeding, or 10½ months after transplanting to the field. In a field having poor drainage the variety made a second-year growth surpassing that of the varieties D–117, S. C. 12/4, and H–109.

The variety makes strong, erect growth, germinates well, and stools heavily, the original stool bearing 24 canes and 9 suckers. The stems are zigzag and tumid, about 4 centimeters in diameter, and of yellowish green color flushed with red. A conspicuous ring of rather short, brownish cracks lies immediately below the glaucous band and sometimes invades the area. The bud is round, exceeding the growth ring

by 3 millimeters, with blunt and ciliated apex, narrow margin, subdorsal germination, and fine, smooth hairs on the shoulders and on the margin below the apex. The growth ring is narrow, undefined, even, and concolorous with the internode. The root band is 4 to 6 millimeters in breadth, concolorous with the internode, and bears 3 or 4 conspicuous rows of rudimentary roots. The leaf scar is glabrous, the glaucous band constricted and wax heavy, and the leaves are green and spreading.

TESTS OF INTRODUCED VARIETIES

P. O. J. 2725, a variety supposed to have come from Java and recently introduced from Tucumán, Argentina, continues to give promising results. This variety has been widely distributed in small quantities among local planters and adapts itself to a wide range of conditions, thriving best where the rainfall is abundant, and also doing very well on poorly drained soils. P. O. J. 2725 will probably supplant varieties more susceptible to mosaic, and also the Uba cane, which is unstable in yield of sucrose and purity. Only one-tenth of 1 per cent of the crop of P. O. J. 2725 has been affected by mosaic disease in Mayaguez, and about 1 or 2 per cent in Tucumán. Planted at the rate of one 3-eyed piece each in holes 5 by 5 feet on a 1/40-acre plat at Mayaguez, P. O. J. 2725 at 13½ months yielded at the rate of 49.7 tons of cane per acre. The crop was not affected when grown on a soil that was under water for three different periods of several days each. Grown on a 1/20-acre plat, P. O. J. 2725 at 18 months yielded at the rate of 77.4 tons of cane per acre. In a mill test at Central Coloso 2½ tons of this cane yielded 15.83 per cent sucrose and a purity of 84.7 per cent. A ton of the cane at 12½ months analyzed 15.25 per cent sucrose and a purity of 82.9 per cent.

Judging by the results obtained in Tucumán, where yields approximate 4 tons of sugar per acre during the relatively short growing season, P. O. J. 2725 should yield 6 to 8 tons per acre in Porto Rico, where the growing season is longer. The variety seems to be very early, arrowing the first part of November. It arrows profusely, beginning at the age of 5 months when planted in June. The variety should not be planted in April, May, or June, if best results are to be expected, because early arrowing tends to reduce yields. As an extra early crop it should be planted during the first three months of the year. The canes are soft and readily attacked by the stalk borer.

A number of other varieties introduced from the Far East by the station include P. O. J. 2727, P. O. J. 2714, Toledo, 36–M (sport of P. O. J. 36), Tekcha, Tjep. 24, and P. O. J. 2725, the last two of which were also introduced earlier from Tucumán. The most promising after the P. O. J. 2725 is variety P. O. J. 2714, which is a thick cane and makes vigorous and rapid growth. However, 20 per cent of the crop proved to be susceptible to mosaic disease at Mayaguez. The variety Toledo, a thin cane resembling the P. O. J. 312, is a prolific stooler and so far has been free from mosaic disease. It is not so vigorous as the variety BH–10/12. Cane P. O. J. 2727 made promising growth. Cane 36–M is very similar to cane P. O. J. 36, from

which it was developed, and 20 per cent of the crop was found to be infected with mosaic disease. The variety Tjep. 24 made rather vigorous growth while young, but slowed down later, whereas nearly all the other varieties rapidly increased in growth. This was true especially of cane P. O. J. 2725, which about doubled its first growth. Cane Tjep. 24 has so far been free from mosaic disease. Cane Tekcha resembles canes of the Japanese type, makes vigorous growth, and seems to be free from mosaic disease.

The following list gives the analysis (percentage) of single stools of the different varieties: P. O. J. 2725, 18.89 sucrose and 85.94 purity; P. O. J. 2714, 17.82 sucrose and 81.44 purity; P. O. J. 2727, 14.35 sucrose and 70.41 purity; Tjep. 24, 15.94 sucrose and 81.87 purity; Toledo, 9.1 sucrose and 50 purity; and Tekcha, 12.8 sucrose and 73.73 purity.

SPACING EXPERIMENT

To determine the optimum planting distance for maximum yield of cane and sugar with thin-stemmed prolific varieties, seed pieces of the varieties Java Unknown and Uba were planted 2 to 6 feet apart in rows 6 feet apart. In another series seed pieces of Java Unknown were planted 2 to 5 feet apart in rows 5 feet apart. Sufficient land was not available for planting the Uba variety in a 5-foot series. Plantings were made in duplicate with three rows per plat, and data were collected only on the middle row, or approximately on each 1/100-acre plat. Drought reduced the stands and necessitated making corrections on yield data for each plat. Table 2 gives the results of planting at the different distances.

TABLE 2.—*Analysis and calculated yield of Java Unknown and Uba cane planted at different distances*

Name of cane	Planting distance	Brix reading	Sucrose content	Purity	Yield of cane per acre	Yield of sugar per acre
	Feet.	*Degrees*	*Per cent*	*Per cent*	*Tons*	*Tons*
Java Unknown	5 by 2	19.43	16.18	82.70	54.000	8.744
Do	5 by 3	19.46	16.37	83.47	29.440	4.968
Do	5 by 4	19.79	16.19	81.69	33.650	5.614
Do	5 by 5	19.57	16.12	82.38	30.750	5.127
Do	6 by 2	19.90	16.76	84.15	43.385	7.272
Do	6 by 3	18.27	12.29	72.80	34.544	4.224
Do	6 by 4	20.28	16.53	81.87	29.250	6.316
Do	6 by 5	20.21	16.97	83.97	39.747	5.183
Do	6 by 6	19.94	16.25	81.48	37.026	5.712
Uba	6 by 2	19.99	17.13	85.65	51.210	8.934
Do	6 by 3	20.15	16.75	83.11	45.960	7.668
Do	6 by 4	20.22	16.68	80.11	30.056	4.867
Do	6 by 5	20.14	15.85	78.67	26.789	4.249
Do	6 by 6	18.92	14.64	78.87	16.552	2.426

The sugar yield for both varieties was highest from the closest spacings, either 6 by 2 or 5 by 2 feet, and, although the sucrose percentages showed no marked differences for the different plats, the purity content tended to lessen with the wider spacing.

CULTURAL EXPERIMENTS

Notwithstanding the many methods followed for propagating the cane seedling, the data available comparing their relative values are

few. To obtain further information on these values, data were recorded on the vitality of seed, mortality, and growth of a number of seedlings which were grown at Mayaguez in the open with and without protection from the sun and wind. The experiment was divided into four parts: (1) Collection, storage, and seeding of arrows; (2) care of germination flats, sunlight exposure, and irrigation; (3) soil mixture, depth, and texture; and (4) optimum age for transplanting from the flats.

Serious loss in vitality of seed took place within three days after collection when fluctuation in moisture content was not prevented. The seed should, therefore, be planted as soon as possible after collection. S. C. 12/4 arrows collected during the last week of December gave a higher germination than did those collected about the middle of January. In a test made to learn the effect of germination of sowing wet arrows in layers varying in thickness from 4.4 to 11.6 millimeters the minimum depth produced the largest number of seedlings per arrow, whereas any marked increase in depth prevented germination of seeds lying at the bottom of the layer. Complete exposure to sunlight resulted in a healthy growth in all stages. Shading during the mornings of the first two weeks after transplanting not only stunted growth but also increased mortality. Seedlings of the variety D–109 increased in growth when they were transplanted at 2 weeks of age and immediately treated with Bayer dust. Deep germination flats gave better results than shallow flats. The month-old root systems of S. C. 12/4 grown in 6-inch flats, were about half as large again as root systems of the same age which were grown in 3-inch flats. Flats in the bottom of which unsifted coarse soil was placed showed a decrease in mortality over flats in which the soil was sifted throughout.

Tests were made in both germination flats and flats for transplanting to determine the comparative effect on cane of clay, powdered charcoal, manure, coconut fiber, and sandy river loam in varying quantities. Clay proved to be undesirable at all times, stunting the crop and increasing mortality. The germination flats made an increased stand when the top inch layer of soil was treated with powdered charcoal (one-third part), whereas the flats for transplanting when similarly treated showed increased mortality. Coconut fiber can not be recommended for use because it retains moisture and proves to be objectionable when the flats are exposed to rain. Well-rotted cow manure mixed to the extent of 50 per cent with sandy river loam, gave satisfactory results in both the germination flats and the flats for transplanting.

Transplanted seedlings grown on a mixture of equal parts of manure and sandy river loam showed a lower mortality than did those on 1 to 2 parts of the same mixture. Fully 30 to 65 per cent of the seedlings transplanted when less than 1 month old died. Seedlings should be transplanted between 60 and 70 days old to lessen the chances for death and facilitate ease in handling. At this age they will be 3 to 5 inches high, and the developing suckers can be used as a basis for roguing. Some of the B–3412 variety of seedlings, which were kept in germination flats 6 inches deep until 4 months old, made

such vigorous growth as to indicate the advisability of sowing deeply and controlling the rate of seeding to avoid the work of transplanting to pots.

ELIMINATING UNDESIRABLE SEEDLINGS

To determine what differences justifying early elimination occur in the growth of canes of varying ages, measurements and observations were made on cane seedlings at 2½, 3½, and 6½ to 7 months. Rather contrasting differences take place in cane seedlings of different varieties less than a month old. At 14 days two typical S. C. 12/4 seedlings were twice the size of two D–117 seedlings. (Fig. 5.) Contrasting differences in germination vigor also occur in S. C.12/4 and P. O. J.–2725 seedlings. At 2 to 3½ months old, seedlings may show a number of differences, many of which persist to maturity. Characteristic seedlings of FC–306 at 2 months are large and many-suckered, with recurved leaves; whereas, S. C. 12/4 seedlings of the same age are medium to large, and few-suckered, with saberlike leaves; and B–6308 seedlings are small, stocky, and many-suckered, with recurved leaves.

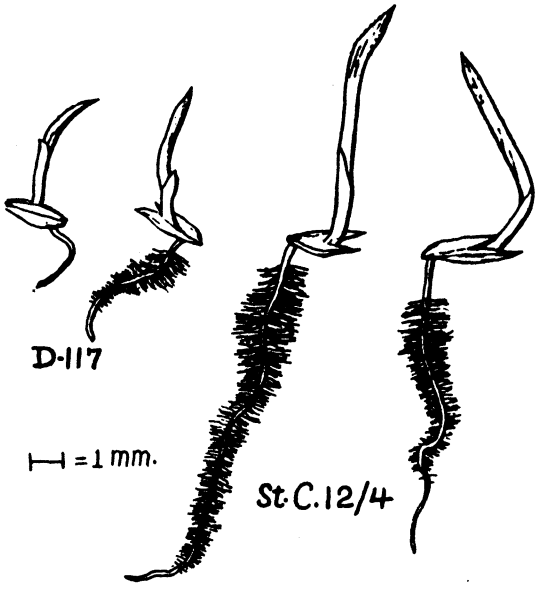

FIG. 5.—At one week differences are observable in cane seedlings of different varieties. The two D–117 seedlings on the left are less than half the size of those of St. Croix 12/4 on the right. (Drawn one week from date of seeding.)

With the exception of seedlings that germinate slowly and those having abnormal leaf coloring, elimination should be postponed until suckering begins, or the plants are 2½ months old. Rarely more than 10 per cent of the seedlings sucker before they are 2 months old. Leaf width, leaf shape, and position of suckers are relatively unimportant characters for elimination purposes because the differences are not sufficiently contrasting except in hybrid progenies of known parentage.

In the elimination work tests were made determining the relation of the early-suckering habit to the size of the stool nearing maturity. Notes were taken on approximately 1,000 seedlings of the varieties S. C. 12/4, FC–306, B–6308, D–433, and D–117. The many-suckered varieties at 2½ months had 10 times as many potentially desirable seedlings approaching maturity as were to be found among the few-suckered varieties of the same age. The superiority of the many-suckered seedlings, selected at 2½ months, is marked at 6½ months. (Fig. 6.) The number of potentially desirable seedlings at 6½ or 7

months may be doubled or trebled by increasing the number of seedlings to be germinated and by transplanting only those having many suckers at 2½ months. The practice of eliminating few-suckered seedlings at 2½ to 3½ months is desirable.

FIG. 6.—The superiority of many-suckered cane seedlings at 2½ months is marked at 6½ months. The row on the left consisting of seedlings of B-6308 selected for three or more suckers at 2½ months has made double the growth of the row on the right, consisting of seedlings with two or less suckers at 2½ months

REPORT OF THE PARASITOLOGIST

By G. DIKMANS

The work in parasitology was begun in 1924. The leading projects under investigation include: (1) A general survey of animal parasites affecting domestic animals in Porto Rico; (2) a study of the life history of *Necator suillus* and its possible relation to the problem of human ankylostomiasis in Porto Rico; (3) paradichlorobenzene as an anthelmintic; and (4) hookworm development in the latrine and the pollution of the surrounding area.

The small intestines of 60 pigs that had been slaughtered at a local abattoir were brought to the laboratory for examination. Of these, 24, or 40 per cent, were found to harbor a nematode provisionally determined as *Crassisoma urosubulatum* Aless 1909. Further detailed study of the nematode is necessary to make the determination abso-

lute. The number of nematodes found per pig ranged from 1 to 800–1,000. Forty per cent of the animals were infested with the thorny headed hog worm (*Macracanthorynchus hirudinaceus*). The common roundworm (*Ascaris lumbricoides*) was found in one animal. Nine of 18 pig stomachs examined contained nematodes. Five had a double infestation of *Hyostrongylus rubidus* and *Arduenna strongylina*. Two contained *H. rubidus* alone, and two others *A. strongylina* alone. The few lungs examined showed a high rate of infestation with lungworms, and a few of the large intestines the presence of *Oesophagostomum dentatum*. The feces of one of the animals was heavily infested with *Balantidium coli*, and several showed cysts of amœbæ.

No cattle were systematically examined, but casual observation in the slaughterhouse showed a high percentage of infestation with the liver fluke (*Fasciola hepatica*). Lung abscesses due to this parasite were found. Post-mortem examination of a calf showed the presence of ticks in large numbers and all stages of growth, *Snygamus laryngeus* in the larynx and upper part of the trachea, large numbers of lungworms, approximately 4,000 stomach worms (*Hæmonchus contortus*) in the abomasum, cattle hookworms (*Bunostomum phlebotomum*), and numbers of Cooperia in the small intestine, whipworms (*Trichuris ovis*), and nodular worms (*Œsophagostomum radiatum*) in the large intestine and cæcum, and liver flukes (*Fasciola hepatica*) in the liver.

The large intestine of one of the station heifers contained some Œsophagostoma and an undetermined species of the genus Capillaria. All the dogs coming under observation were infested with hookworm (*Ankylostomum caninum*). A number of the dogs harbored also roundworms, tapeworms, and coccidia. A cat was found to harbor a female hookworm (*A. caninum*). Chickens, turkeys, and one guinea hen harbored nematodes, cestodes, and trematodes. Unidentified ticks were collected from cattle, horses, and dogs and goats. Specimens of the horn fly (*Hæmatobia irritans*) were collected from animals in the dry section of the island. The fly was not found on the station animals, but some observations concerning the extent of its range and possible remedial measures may be desirable. Larvæ of the ox warble (*Hypoderma* sp.) were taken from imported cattle. Deer flies were seen in negligible numbers. Two imported animals which were infested with lice were clipped and sent to the dipping vat.

Examination of nematodes, taken from pigs at a local abattoir, failed to show the presence of *Necator suillus*. Comparatively few pigs were examined, however, and further observations may reveal its presence here or in some other part of the island. Unsuccessful attempts were made to infect pigs with the hookworm of man, confirming the results obtained by others making similar tests. Ackert's findings regarding the possible dissemination of the human hookworm by pigs were confirmed. He showed that eggs pass unharmed through the digestive tract of the pig and hatch in the feces. Apparently the pig is a factor to be reckoned with, since it may act as an agent in spreading hookworm infection, although immune to the disease itself.

Experiments to determine the efficacy of paradichlorobenzene as an anthelmintic were begun in March, 1924, about four months before the other work in parasitology was started. Experimental data are being prepared for publication.

The fourth project has received the greater part of the parasitologist's time and attention. For the purpose of the investigation, four pits 24 by 24 by 30 inches deep have been constructed. It is planned to reproduce in these pits as nearly as possible conditions as they actually exist in the pit latrine. Material known to contain hookworm eggs is to be placed in the pits and the material, the walls of the pit, and the soil surrounding the pit are to be examined for the presence of infective hookworm larvæ. The work is progressing slowly but satisfactorily and is too new yet to permit drawing conclusions.

In addition to his regular duties, the parasitologist acted as veterinarian of the station. The general health of the station animals was excellent. The usual cases of lameness in work oxen caused by traveling for long distances on hard roads were remedied by bathing the affected parts with a mixture of lead acetate and zinc sulphate (3 drams each) and water (1 pint), and by resting the animals for a week or 10 days. Post-mortem examination of an apparently healthy young animal which was found dead revealed an inflamed mucous membrane of the digestive tract. No other pathology was noted. The animal had had access to a solution containing arsenic, and probably died of poisoning. Post-mortem findings of an imported Shorthorn bull dying after a short illness disclosed conditions indicative of tick fever. The findings, however, could not be confirmed by blood examination. Two imported Guernsey bulls are suffering from a skin affection. The older of the animals has been at the station for several years and has had the disease for at least three years, practically the entire body being affected. The younger animal arrived at the station a year ago and has had the disease about four months, the ears alone being affected. No etiological factor has been isolated so far. Skin scrapings were submitted to the veterinary laboratory, Army Medical School, Washington, D. C., and to Bailey K. Ashford, School of Tropical Medicine, San Juan, P. R. The Army Medical School reports entirely negative findings. Doctor Ashford reports the finding of a new species of Monilia on the skin scrapings sent to him, and has prepared a vaccine of this organism. The animal is being treated with the vaccine at present.

REPORT OF THE PLANT PATHOLOGIST

By C. M. TUCKER

COCONUT BUD ROT

Work on coconut bud rot was continued and a manuscript giving results of the investigations was submitted for publication.[3]

The results briefly summed up are as follows: *Phytophthora palmivora* (*P. faberi.*) is the causal organism of coconut bud rot in Porto Rico as it is in Jamaica, the Philippines, and India. The disease is transmissible from diseased palms to healthy, uninjured ones. The incubation period may vary from 2 to 10 months or longer. Organisms of the *Bacillus coli* type are present in decaying buds, but are not pathogenic. Inoculations made by wounding the bud are practically of no value, because the palms may be killed by decay of the most aseptically treated wounds. Conditions favorable to the disease

[3] Phytophthora bud rot of cocoanut palms in Porto Rico. U. S. Dept. Agr., Jour. Agr. Research, 32 (1926), No. 5, pp. 471-498.

include heavy rains and decreased evaporation occuring in sheltered locations and poorly drained soils. The earliest visible symptom of the disease is the death of the youngest leaf. (Fig. 7.) The most important period of infectiousness follows exposure of the young dead leaf bearing conidia and chlamydospores. As a control measure all infected palms should be destroyed as soon as the disease is detected. The strain of *P. palmivora* obtained from coconut bud rot, although indistinguishable physiologically and morphologically from some cacao-infecting strains, was not found to be pathogenic to cacao pods or seedlings. (Fig. 8.) Efforts to transmit coconut bud rot by means of infected seeds were not successful. Inoculations of dry, ripe coconuts resulted negatively, since the water-loving Phytophthora was unable to establish itself and the half-ripe inoculated nuts decayed and failed to germinate. These results agree with those obtained when the young seedlings are free from disease.

FIG. 7—Coconut bud rot produced by pouring a water suspension of of a pure culture of *Phytophthora palmivora* among the unwounded, unfolding leaves. Photographed 121 days after inoculation

The legislature of Porto Rico has enacted a law enabling the commissioner of agriculture and labor to take precautionary measures to combat plant pests and diseases. Coconut bud rot is the first fungus disease to be dealt with under the new law, and all diseased palms have been ordered destroyed. The plant pathologist is now acting in an advisory capacity in the campaign for the eradication of the disease.

LIGHTNING INJURY TO COCONUT PALMS

Occasionally lightning strikes and kills palms. In one case observed 11 palms occupying a circular area 50 to 75 yards in diameter were killed by the same bolt of lightning and leaf midribs were broken and leaves killed on the sides of the palms adjoining the damaged area. Lightning-struck palms show symptoms which can readily be distinguished from those caused by bud rot. Phytophthora bud rot destroys the bud and causes the death of the youngest leaves. The

older leaves may retain their green color and horizontal position for many months. When palms are struck by lightning the petioles collapse and the leaves turn brown and hang pendant from the crown. (Fig. 9). Bud rot is more likely to kill palms scattered over a wide area than it is to take all the palms of a restricted area.

A ROOT DISEASE OF VANILLA

Investigations to determine the cause and control of vanilla root disease have been previously described.[4] The rather unsatisfactory percentages of infection of inoculated plants grown in sterilized fiber is found to have been due to an inhibitory substance, probably tannin, which was produced during autoclaving of the moist fiber. Subsequent inoculations made in soil established the pathogenicity of the fungus (*Fusarium* sp.).

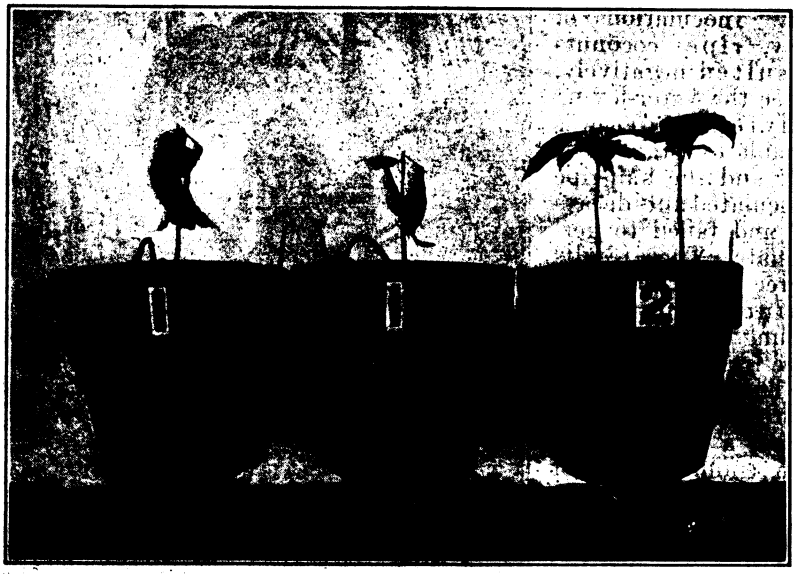

FIG. 8—Cacao seedlings inoculated with *Phytophthora palmivora* strains. (1) Inoculated with *P. palmivora* from cacao; (2) inoculated with *P. palmivora* from coconut. The coconut strains showed no evidence of pathogenicity to cacao. Photographed eight days after inoculation

A study was made comparing the growth of roots in situ in sterilized soil and in inoculated soil. Large plugged glass tubes of inoculated soil were used to receive surface sterilized descending aerial roots. The tubes when tied to the support on which the vine clings permit normal root development. One hundred per cent of the roots in the Fusarium-inoculated soil became infected, whereas all those in the tubes of sterilized soil remained healthy.

The fungus is able to grow in a soil when deprived of a living host and remain in a virulent condition for at least four years. The pathogenicity of the fungus has been shown to be due to the destruction of the cortex by a cytolytic enzyme causing the cell walls

[4] Rpts. Porto Rico Sta. 1923, p. 15; 1924, p. 28.

to turn brown and dissolve. The cambium and ducts are invaded only after destruction of the cortex cells is well advanced, and in no case observed were the hyphæ in the ducts developed sufficiently to prevent the passage of nutrients as occurs in cases of infection by

FIG. 9.—Coconut palm killed by lightning. Compare with bud-rot infected palm in Figure 7. In the right foreground may be seen a portion of a palm leaf hanging from a broken midrib. This type of damage is common on palms adjacent to those killed by lightning. It never accompanies bud rot

F. vasinfectum. Unsuccessful attempts were made to isolate the fungus from tissue taken from the margin back of the decayed area of diseased roots, further indicating that the fungus is not a vascular parasite. *F. cubense* has been shown to produce a toxic product causing cut banana plants to wilt when placed in filtrates of culture

solutions in which the fungus has been grown. Similar work with the vanilla Fusarium failed to cause wilting of bean and cotton seedlings.

Vanilla plants were successfully inoculated when the root organism was placed in wounds made in the stems. The internodes rotted, resulting in the death of the plant above the point of inoculation, in all cases except where new roots formed and came in contact with the soil. *F. cubense* failed to produce a diseased condition.

The problem of vanilla root disease is similar in some respects to that of banana wilt. Both diseases are caused by a Fusarium which is able to persist in infected soils for long periods. Vegetative propagation is commonly practiced with both host crops, and each shows varietal or specific variation in susceptibility. The vanillon, an inferior type of vanilla, is highly resistant. The vanilla plant produces germinable seeds, and resistant, valuable hybrids may be obtained by crossing it with the vanillon. Vanilla plantings have been reported usually as remaining healthy for three or four years. The crop develops best on a substratum of decaying matter and is for this reason frequently treated with forest rakings. Decomposition of the organic matter produces acid conditions which probably favor the growth of the Fusarium. Several series of pots are being prepared with soil reactions varying from pH 5.4 to pH 9.8 to determine their effect on the disease.

COTTON FUNGUS

Sea-island cotton is annually attacked by a fungus which spots the leaves, bracts, and bolls. The disease commonly occurs at Lajas, Isabela, and Quebradillas, the principal cotton-growing sections of the island. The leaves show circular, rather conspicuous, dark purple spots, which gradually bleach and turn gray in the center. Many of the centers drop, leaving the leaves with jagged holes. The bracts are similarly attacked. The bolls show a small purple spot which does not enlarge nor become ashen in the center. The fungus has not been observed to penetrate the boll. The causal organism is a Helminthosporium, which has been described as a new species, *H. gossypii*.[5] The fungus sporulates freely on the ashen centers of old spots, and has been isolated in pure culture. It grows on a wide variety of artificial media, but produces spores most abundantly on sugar-containing media. Leaves and bracts bear typical spots developing sufficiently for identification in three weeks when inoculated by spraying with a water suspension of spores and mycelim. The spots are well developed in five days. (Fig. 10.)

Unlike many leaf-spot diseases, the cotton leaf-spot disease is severe in dry weather. Examination of a field at Lajas during a drought so severe as to cause stunting of the plants showed spotting on nearly every leaf and partial defoliation of many of the heavily infected plants. Much new growth was found in the same field after about three weeks of rain, and the young leaves were then practically free from infection. Destroying all plants between seasons, as is done to combat the pink bollworm, probably would help to decrease the damage done by *H. gossypii*.

[5] U. S. Dept. Agr., Jour. Agr. Research, 32 (1926), No. 4, pp. 381-395.

STRAINS OF TROPICAL PHYTOPHTHORAS

An investigation to facilitate the work of identifying Phytophthoras attacking various tropical plants has been begun, comparing morphologically and physiologically 45 strains isolated from cacao, coconut, cotton, breadfruit, papaw, citrus, abaca, tomato, eggplant, *Odontodenia speciosa*, *Dendrobium maccarthiæ*, Hevea, Erythrina, Borassus, and *Hibiscus sabdariffa*. Cross inoculations also are being made. The results thus far indicate considerable variation in cultural characteristics on the media, including potato dextrose agar, potato agar, coconut agar, beef dextrose agar, oatmeal agar, and bean agar, used to make comparisons. Morphological variations in the size and shape of sporangia and size of chlamydospores seem to be fairly constant for various strains, but the variations are narrow. Probably the most striking characteristic is the highly specialized pathogenicity of the strains. In most cases a strain will cause disease only in the host plant from which it is isolated.

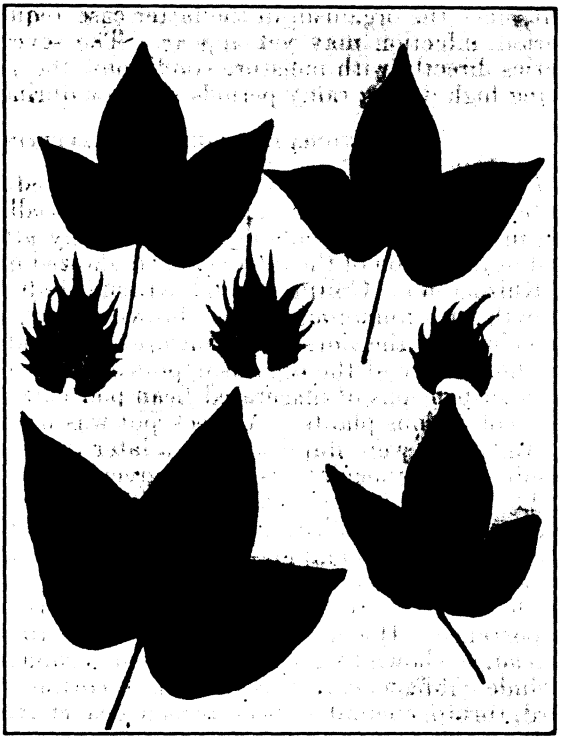

FIG. 10.—Spots on sea-island cotton leaves and bracts produced by spray inoculation with *Helminthosporium gossypii* n. sp. Photographed five days after inoculation

Great care is exercised to prevent the escape of imported strains. Phytophthoras of the faberi-palmivora type have been isolated from coconut, cotton, and tomato in Porto Rico, but the possibility of introducing strains pathogenic to other hosts or more virulent strains is always present. Inoculations of fruits and seedlings are always made in the laboratory under cover and all material is destroyed later by autoclaving; and the glass slides which are used to examine the strains under the microscope, are immediately washed in a solution of mercuric chloride.

Heterothallism has been demonstrated between some strains by other investigators, and the present investigation is intended to test the possibility of oogonia formation with all possible combinations of the 45 strains. Seventeen strains have been grown together to date. In each instance where oogonia have been found one of the inoculating

strains has been isolated from cacao. Two strains from cacao in Trinidad and one strain from cacao in Ceylon produce oogonia when grown in mixed cultures with some of the other strains. All oogonia so far found have been of the *P. parasitica* type.

Phytophthora boll rot of cotton was found in Porto Rico for the first time during the year. A small station planting bearing bolls during the rainy season became infected. The Phytophthora was isolated and reproduced the disease when used to inoculate healthy bolls. The fungus apparently is of the faberi group, but exhibits many dissimilarities to the coconut bud rot strain. Inoculations of coconut palms with the cotton strain have not resulted in bud rot, but, since the organism in the latter case requires a long incubation period, infection may yet appear. The severity of cotton boll rot varies directly with moisture conditions, the percentage of infection being high during rainy periods and low during dry periods.

RHIZOCTONIA FERRUGENA AS A SEEDLING PARASITE

Rhizoctonia ferrugena originally was isolated from the roots of sugar cane. During the year some pigeon-pea seedlings which were growing in pots in the greenhouse were severely attacked by damping-off, and examination of the infected parts showed mycelium characteristic of Rhizocton a. Cultures from the tissue produced typical *R. ferrugena* growth with numerous reddish brown sclerotia and masses of brown mycelium on the sides of the culture tubes and flasks. To determine the host range of the organism, pots of sterilized soil were inoculated with suspensions of macerated bean pod cultures and sown with the seeds of various plants. A check pot was used in each instance, and all the series were duplicated at a later date. On y a résumé of the results of the inoculations can be given here.

The type of injury varies with different hosts. In some instances the seedlings are killed before reaching the surface of the soil, and in others a typical damping-off is evident during the first two weeks growth. Apparently the fungus is unable to enter the tissue once it hardens. As a root parasite the fungus is probab y not of great importance. Hosts which are very susceptible to attack by *R. ferrugena*, as shown by great y decreased germination or by damping-off include cabbage, carrot, Swiss chard cotton, sweet pea, onion, mustard, turnip, cucumber, beet, pigeon pea, chayote, bean, spinach, and lettuce. Tomatoes and *Crotalaria juncea* are only slightly susceptible, and corn, sugar cane from cuttings, sweet potatoes, and Bermuda grass are not damaged.

Experiments to determine the effect of var ous percentages of soil moisture on infection were conducted with beans, pigeon peas, and cotton. Thirty pots of sterilized soil were used for each host. The pots were divided into six groups of five pots each, and all the pots in the same group were given the same amount of water daily. One pot in each group was left uninoculated to serve as a check. Twenty-five seeds were planted in each pot. The average soil moisture was determined by samples taken twice daily. Table 3 gives the results of the test.

TABLE 3.—*Effect of soil moisture on Rhizoctonia ferrugena infection*

Crops	Average soil moisture	Proportion of healthy plants to number of seeds planted		Decrease resulting from inoculation
		Check	Inoculated	
	Per cent	*Per cent*	*Per cent*	*Per cent*
Pigeon peas [1]	34.13	40	3	3/
	32.68	70	19	51
	29.03	76	17	59
	16.26	90	55	35
	14.23	84	14	70
	8.71	90	8	82
Cotton [1]	35.88	84	23	61
	32.63	76	24	52
	27.42	80	22	58
	24.34	72	4	68
	16.61	72	3	69
Bean [2]	34.69	60	17	43
	32.91	88	23	65
	30.46	64	24	40
	27.14	80	30	50
	23.19	72	32	40
	16.45	68	44	24

[1] Data taken 20 days after planting.
[2] Data taken 15 days after planting.

The percentages in the check column were obtained from only 25 planted seeds, whereas those in the inoculated column were obtained from 100 planted seeds. A comparison of the percentages in the latter column is therefore of more value as an index of the effect of varying percentages of soil moisture on infection than is a comparison of the decreases due to inoculation because of the wide variations in germination in the check pots.

Although the results of the experiment are not considered conclusive, they indicate that, in the case of the pigeon pea and the cotton, infection is more serious on dry than on wet soils, whereas, in the case of the bean, the reverse seems to be true.

ANTHRACNOSE OF PIGEON PEA

Anthracnose of the pigeon pea, due to *Colletotrichum cajani*, although previously reported only from Brazil, and possibly from Barbados, has probably been present in Porto Rico for many years, since specimens have been received from widely separated points. The disease is readily recognized by the appearance on the pods of lesions resembling those occurring on beans infected with *C. lindemuthianum*. Since the pod of the pigeon pea is chartaceous rather than succulent, the lesions are more like spots than cankers. In damp weather the centers become pinkish gray, owing to the formation of masses of conidia. The fungus penetrates the pod and enters the seeds, causing them to decay or to fail to develop. Very early infection may cause the pod to shrivel and fall. (Fig. 11.)

In January, 1925, diseased and healthy pods were picked from 10 plants in the station grounds. The pods were at the green-pea stage, at which time they are edible. The peas were shelled and graded as marketable or unmarketable—that is, shriveled or discolored by the fungus. Table 4 shows the number and percentages of diseased and healthy pods and the number of marketable peas per pod.

TABLE 4.—*Marketable seeds in healthy and diseased pigeon pea pods*

Marketable seeds per pod	Diseased pods		Healthy pods	
Number:	*Number*	*Per cent*	*Number*	*Per cent*
0	66	12.1	0	0
1	84	15.4	0	0
2	101	18.5	0	0
3	144	26.5	21	24.7
4	121	22.3	52	61.2
5	28	5.2	12	14.1
Total	544	100.0	85	100.0

The 544 diseased pods yielded 1,342 marketable seeds; whereas from a like number of healthy pods a yield of 2,118 seeds would be expected. The loss attributable to the fungus is 776 seeds, or 36.6

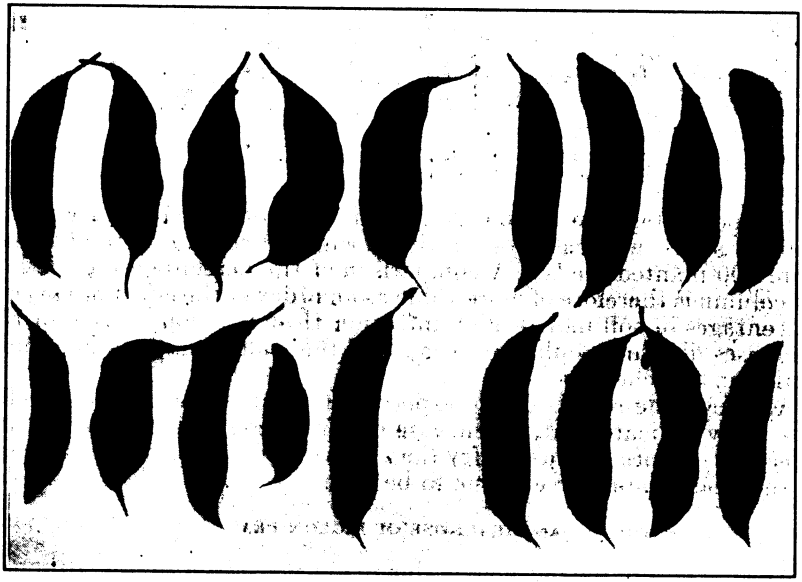

FIG. 11.—Left, pigeon pea pods spotted and distorted by *Colletotrichum cajani*. Right, healthy pods

per cent. Some varieties which are thought to be resistant to infection are to be tested. Attempts to inoculate varieties of beans, including Giant Stringless Green Pod, Pencil-Pod Black Wax, and Refugee, resulted negatively. Parallel inoculations of small pigeon peas resulted in 100 per cent infection, one or more leaves on each plant showing a blackening and shriveling of the veins. All inoculations were made by spraying the plants with an atomizer containing a water suspension of conidia.

STEM CANKER OF PIGEON PEA

Stem canker of pigeon peas every year kills many plants in Porto Rico. The cankers most commonly occur near the ground, but may be found on nearly any woody part of the plant. The wood is killed and becomes brown in elongated areas gradually involving the whole stem. (Fig. 12.) Fragments of brown mycelium were to be seen in scrapings from the diseased wood, and perithecia of a Botryosphæria

were found on the bark. The Botryosphæria was identified by C. L. Shear as *B. xanthocephala*, which attacks the pigeon pea as a saprophyte in India. Cultures from the interior of cankers yielded a brown fungus which is probably the Botryosphæria, although no fruiting bodies have been produced. The results of inoculations with the pure culture are yet uncertain.

A PHYSIOLOGICAL DISEASE OF SISAL

In 1923 attention was directed to a disease of sisal. The affected plants could be distinguished at considerable distance by their yellow, drooping leaves. The leaves had sunken areas of shriveled, yellow, corky tissue varying from a few millimeters in diameter to elongated patches covering nearly the whole of the blade. The mottled appearance suggested a type of mosaic. Affected plants ceased growing, and the yellowing, at first confined to older leaves, gradually extended to even young leaves which had not emerged from the central bud. Plants of all ages were attacked and a number died.

FIG. 12.—Sections of cankered pigeon-pea stems with the bark cut away to show the areas of brown infected wood.

Examination of plants in the incipient stage of disease showed the presence of small, apparently water-soaked, circular areas which proved to be translucent when the leaves were held to the light. Sections of translucent and corky areas failed to reveal the presence of any organism. The corky areas were a series of collapsed and dried mesophyll cells. Plantings of both stages in various culture agars failed to give any growth whatever from bits of tissue removed from the interior of the affected areas. Plants in various stages of the disease when examined showed dying roots in the more advanced stages, but no symptoms attributable to a root disease in the earlier stages. Sisal was severely affected, and some henequen growing in the same locality to a much less extent.

The affected plants were grown on hillsides in a soil of very unproductive heavy yellow clay. The very severe drought of the winter coupled with the torrential rains of the summer rendered the soil almost untillable and probably caused the death of the crop. A dozen young plants which were apparently in the last stages of disease showed complete recovery one year later when transferred to alluvial loam having good drainage. The yellow had been replaced by green and growth was normal. The return to normal of the color would

seem to indicate that yellowing was due to physiological causes rather than to parasite invasion. Recovery of affected parts could hardly be expected in the latter case. Leaf areas which collapsed and became suberized did not recover, but surrounding tissues regained their normal green color and turgidity.

Crosses between henequen and sisal were made to establish progeny combining the disease-resistance ability of the former with the desirable qualities of the latter. The resulting progeny already exhibit great variety in characters, and their ability to resist disease is being watched with interest.

TOMATO DISEASES

Wilt (*Bacterium solanacearum*) is one of the most destructive diseases of the tomato in Porto Rico. The bacteria are thought to gain entrance to the roots through wounds caused in transplanting or later by nematodes, and an effort is therefore being made to prevent infection by immersing roots for transplanting in an approximate ¼ per cent Uspulun solution. Applied in this strength Uspulun is toxic to the bacteria, and apparently not injurious to the plant. Plants when transplanted to dry soil and treated with the solution have grown as well as those receiving only water. The results of using the disinfectant in infected soil are not yet ready for publication.

In a test with 36 varieties of tomatoes and hybrids an average of 60 per cent of the plants became affected with bacterial wilt. The different varieties exhibited considerable variation in number of diseased plants, but no variety showed high resistance to infection. The variety Truckers' Favorite had a mortality of 100 per cent before setting fruit. (Fig. 13.)

Nematode root knot is another serious trouble in tomato growing. Comparisons of seed bed treatments were made, using steam-sterilized soil, formaldehyde (1 part formalin to 50 parts water applied at the rate of one-half gallon per square foot), Uspulun (¼ per cent solution applied at the rate of one-half gallon per square foot), and heavily infected untreated soil. The untreated soils, and Uspulun and formaldehyde treated soils resulted in an infection of 100 per cent of the seedlings. No infection took place in the steam-sterilized soil. The average height of the root-knotted plants was 3.85 inches and of the healthy plants 6.34 inches three weeks after planting. The measurements were from root tip to tip of the youngest leaf.

A ROOT ROT DISEASE OF HIBISCUS

Seedlings resulting from crosses between various varieties of ornamental hibiscus were attacked by a root disease causing wilting and yellowing of the leaves and eventually the death of the plant. An unidentified Pythiumlike organism was isolated from infected roots, but proof of its pathogenicity has not been attempted. The disease is interesting because it was not observed on any of the parent plants. Since the plants are usually propagated by cuttings, only resistant individuals probably have survived.

MISCELLANEOUS PLANT DISEASES

The following plant diseases were observed in Porto Rico during the year:

Avocado.—Anthracnose (*Colletotrichum glœosporioides?*). Green specimens of fruit from a plantation in Villalba, where many varieties

are cultivated, bore spots which were typical of anthracnose. The variety Fuerte was reported to be the most susceptible to the disease. The spotted areas were dark brown, roughly circular, with small black pimples in the center, and, as the fruits matured, became enlarged, sunken, and covered with dirty white masses of conidia, corresponding

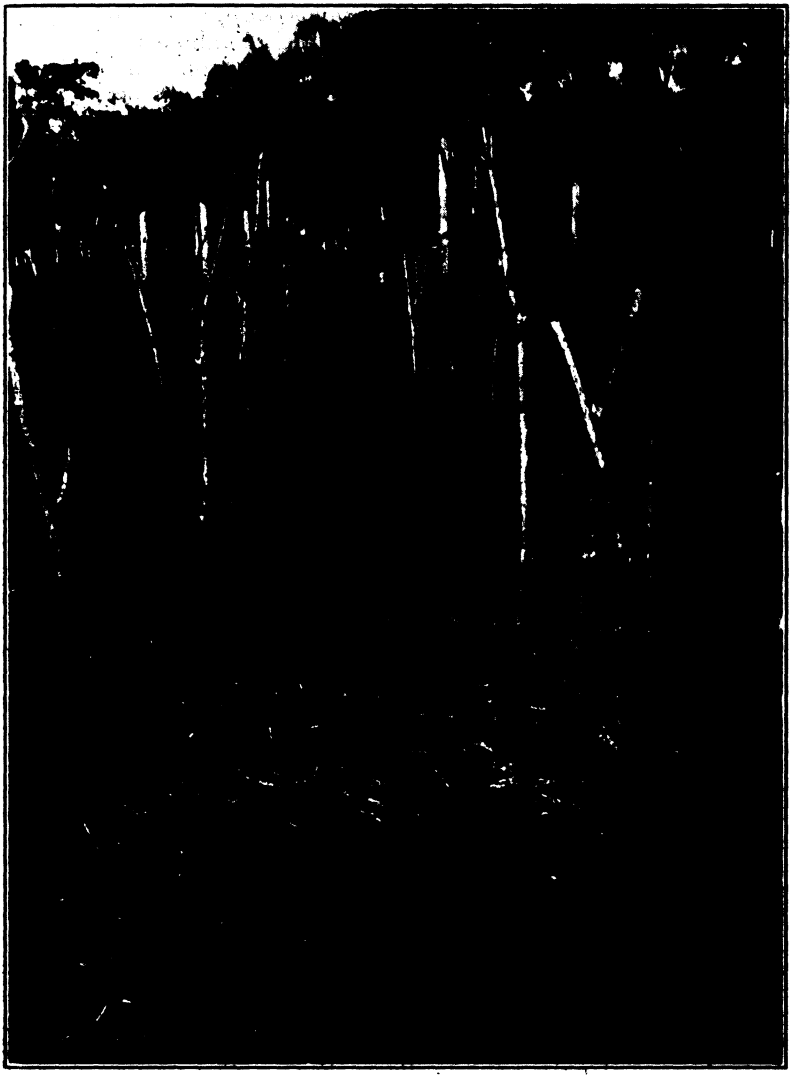

FIG. 13.—The two middle rows are Truckers' Favorite tomatoes. Every plant is infected with bacterial wilt

closely with descriptions of *C. glœosporioides*. Cross inoculations are desirable to determine whether the fungus will infect citrus, and possibly the mango.

Banana.—Anthracnose (*Glœosporium musarum*) attacked mature fruits, spotting the skin with brown. Wilt (*Fusarium cubense*) was

very destructive, especially to the variety locally known as Chamaluco. The variety Gros Michel also proved to be susceptible to the disease.

Bean.—Damping-off (*Pythium debaryanum*) severely attacked germinating beans during the rainy period. The fungus has not been previously recorded on beans in Porto Rico. Rhizoctoniose, or hollow stem, was commonly found. Rust (*Uromyces appendiculatus*) proved to be destructive to beans growing in the greenhouse. Leaf spots (*Cercospora* spp.) were so abundantly present in some instances as to cause the leaves to dry and fall. Often two distinct species of Cercospora were present on the same plant. Mosaic disease was frequently observed, the affected plants showing the characteristic symptoms of curling, dwarfing, and mottling. Powdery mildew (*Oidium* sp.) damaged some plants in the greenhouse, and was favored by conditions promoting the growth of the more destructive disease, anthracnose (*Colletotrichum lindemuthianum*). The latter was prevalent only during the cooler season, and was not controlled by spraying with Bordeaux mixture.

Beet.—Leaf spot (*Cercospora beticola*) did considerable damage during wet weather.

Breadfruit.—Rust (*Uredo artocarpi*), seldom found and does negligible damage. Algal leaf spot (*Cephaleuros virescens*), not important.

Cabbage.—Black rot (*Pseudomonas campestris*) destroyed the crop when continuously planted in the same place. Leaf spot (*Alternaria brassicæ*) was found only on old leaves.

Cane.—Leaf spots (*Helminthosporium sacchari*), *Leptosphæria sacchari*, and *Phyllosticta sacchari*). *H. sacchari* was commonly present on old plants and proved fatal to some seedlings. Seedlings at the station were infected severely during even the driest months. The pycnidia of *Phyllosticta sacchari* and the perithecia of *Leptosphæria sacchari* were often found in the same spots, suggesting a possible connection of the forms. Red spot of the leaf sheath (*Cercospora vaginæ*) proved to be of slight importance. Root diseases which may be of considerable importance were found. Soil conditions play an important rôle in determining the amount of damage caused by organisms. Apparently varietal susceptibility varies considerably. Mosaic disease was very serious on susceptible varieties, many of which are being replaced by immune canes.

Cantaloupe.—Downy mildew (*Peronoplasmopara cubensis*) was widely prevalent and increased in virulence with the advent of the rainy season. Under normal conditions the disease may be controlled by spraying with Bordeaux mixture. Usually, leaf spot (*Cercospora* sp.) causes damage resembling that done by downy mildew, and the two diseases may be found on the same leaf.

Cassava.—Leaf spot (*Cercospora* sp.).

Citrus.—Scab (*Sphaceloma fawcettii*) (*Sporotrichum citri*), is the most serious disease of grapefruit in Porto Rico. The groves along the northern coast are very liable to infection. The trees at the station showed little infection this year, but the leaves appearing during the summer are severely attacked. The absence of fruit infection is due to high temperature and scanty rainfall in the blossoming period. Anthracnose (*Colletotrichum glœosporioides*) was occasionally found on the leaves. Not important in this section. Sooty mold (*Capnodium citri*) is common. Algal leaf spot (*Cephaleuros virescens*).

Coffee.—Thread blight (*Corticium koleroga*), which covers the leaves with mycelium causing their death, spreads by means of mycelial strands which follow the branches and twigs. Often the dead leaves remain hanging from the twigs by threads, suggesting the name of the disease. Infection is general during the rainy season, but the damage done locally is not great, probably because the fungus is well checked by the severely dry winters. White-root disease (cause undetermined) is the most destructive of the diseases affecting the station plantings. The earliest symptoms are yellowing and wilting of the leaves. The fungus may be seen at the collar of the trees, where it is present in white strands and patches on the base of the trunk and the roots. Black-root disease (*Rosellinia bunodes*). The symptoms of the black-root disease are similar to those of the white type, differing only in the black fungus which is found at the base of the trunk. The black type is probably more prevalent locally than the white type, but is not present in the trees at the station. Leaf and berry spot (*Cercospora coffeicola*), although usually present, does not cause serious loss. Leaf spot (*Omphalia flavida*), the serious disease of higher altitudes, is not found at the station.

Corn.—Leaf spot or streak (*Helminthosporium turcicum*) is a conspicuous and occasionally serious disease, causing elongated, bleached, dead areas in the leaf blades, in the centers of which the brown conidiophores and conidia of the fungus are plainly visible. Root rot (*Fusarium moniliforme*) has been prevalent at the station in low, poorly drained soils. Loss from the disease varies greatly from year to year. Bacterial wilt (*Aplanobacter stewarti*) severely attacked a planting of hybrids growing on low ground. The hybrids were the result of crossing field and sweet corn. Rust (*Uredo pallida*) is usually present, but does negligible damage. Smut (*Ustilago zeæ*) rarely attacks more than a few plants in a field. The disease is conspicuous when it is present.

Cotton.—Leaf, bract, and boll spot (*Helminthosporium gossypii*). (See p. 28.) Areolate mildew (*Ramularia areola*) is an important fungus disease of cotton leaves under humid conditions. Rust (*Kuhneola gossypii*) frequently occurs on cotton growing wild and on sea-island cotton. Leaf spot (*Phyllosticta malkoffii*) resembles that caused by *Helminthosporium gossypii*, but is of much less importance. Not previously reported from Porto Rico. Phytophthora boll rot (*Phytophthora palmivora*) is of importance during wet weather only. It attacks the bolls, causing them to turn black. The lint and seeds are destroyed. The fungus is not important on cotton in Porto Rico where the crop is matured during the dry season. Not previously reported from Porto Rico. (See p. 30.) Fusarium boll rot (*Fusarium* sp.) is destructive at Mayaguez during the rainy season. Diplodia boll rot (*Diplodia gossypina*). Damping-off (*Rhizoctonia* sp.).

Cucumber.—Downy mildew (*Peronoplasmopara cubensis*), a serious hindrance to cucumber culture, may be controlled by spraying with Bordeaux mixture, unless the rainfall is very heavy.

Eggplant.—Leaf spot and fruit rot (*Phomopsis vexans*) are widely prevalent and destructive during damp weather.

Gliricidia maculata.—Thread blight (*Corticium koleroga*) attack may assume some importance, especially in regions where a well-defined dry season does not hold the fungus in check.

Grape.—Powdery mildew (*Oidium* sp.) is severe on leaves and young fruits, often causing them to drop. Rust (*Physopella vitis*) generally severely attacks the leaves.

Guava.—Anthracnose (*Glomerella cingulata*).

Hibiscus.—Root disease (undetermined Phycomycete). (See p. 34.)

Lettuce.—Leaf spot (*Cercospora lactucæ*) is commonly found on the older leaves. The disease is not important during dry weather, but renders the plant practically unsalable during wet periods.

Mango.—Anthracnose (*Colletotrichum glœosporioides*) causes the death of the flowers and very young fruit during rainy weather. At Mayaguez the fruit trees blossom during a very dry period and a good crop usually sets. In some sections little production is obtained because of rains during the blossoming season. The fungus also causes spots on the leaves. Sooty mold (*Meliola mangiferæ*) is usually present as a black coating on the leaves. Trunk galls (cause undetermined) apparently cause no harmful effects. The large galls frequently form on the trunks and large branches. Leaf spot (*Pestalozzia guepini*) is common but not severe.

Okra.—Leaf mold (*Cercospora hibisci*) is nearly always present on the under sides of leaves which are nearly covered by the dark conidiophores and spores. The leaves turn yellow and fall, and the photosynthetic area is often reduced to a few young leaves at the top of the stalk.

Onion—Anthracnose (*Colletotrichum circinans*) attacks onions of the white type. In localities where the disease is severe losses may be avoided by planting colored varieties. Leaf blight (*Macrosporium parasitica*) causes drying and shriveling of the leaves. It is not of much importance at Mayaguez.

Peanut.—Rust (*Uredo arachidis*). Leaf spot (*Cercospora personata*).

Pepper.—Leaf spot (*Cercospora capsici*) is a widely prevalent disease causing considerable loss. The spots are large and bleached, and cause infected leaves to fall, often resulting in nearly complete defoliation. Anthracnose (*Glœosporium piperatum* and *Colletotrichum nigrum*) attacked approximately half the plants in one planting. The fungi cause rotting of the ripening fruits. Wilt (*Fusarium* sp.) has been prevalent in heavy soils. Infected plants wilt during the day and revive at night for a short time, then turn yellow and fall. Sixteen per cent of the plants on heavy soil (clay) were killed by the disease. Usually the attack was delayed until the plants were fruiting. Investigation will be necessary to determine the exact species found in infected stems. Not previously reported from Porto Rico. Mosaic disease affected plants received from San Germán. The leaves were wrinkled, dwarfed, and distorted, and the internodes were shortened, producing a bunchy effect at the top of the plants. The plants failed to produce, and the leaves failed to show the yellow mottling characteristics of the disease in beans. Southern wilt (*Sclerotium rolfsii*) occasionally kills a plant, but the disease is less important than the Fusarium wilt.

Pigeon pea.—Rust (*Uromyces dolicholi*) is very commonly present, especially on old leaves, but apparently is not very destructive. Anthracnose (*Colletotrichum cajani*) is present on pods and leaves (See p. 31.) Stem canker (*Botryosphæria xanthocephala*) is a serious disease causing the death of many plants. (See p. 32.) Damping-off (*Rhizoctonia ferrugena*) is very destructive to seedlings during wet

weather. (See p. 30.) Leaf spots (*Velosiella cajani*, *Cercospora instabilis*) are commonly present. The spots are rather inconspicuous and are similar to those caused by *Colletotrichum cajani*, and are not very important. The genus Velosiella was separated from *Cercospora cajani*, on account of the catenulate conidia.

Rice.—Brown spot (*Helminthosporium oryzæ*) has assumed considerable importance in variety trials at the station. Fifteen per cent of the seedlings die as a result of the fungus invading the roots and collar. Older plants are attacked and the leaves thickly spotted. Spots appear also on the glumes and the fungus is transmitted to the seed. Efforts to control the disease by treating the seed with formaldehyde, Uspulun, copper sulphate, and hot water have not given sufficient success to justify recommendation of seed treatment. Blast (*Piricularia oryzæ*) is not of frequent occurrence.

Rose.—Powdery mildew (*Oidium* sp.) was found on leaves of roses received from Salinas. It yields readily to fungicides. Leaf spot (*Cercospora rosicola*) is abundant but not destructive.

Roselle.—Root disease (*Rhizoctonia* sp.?) was noted for the first time during the year. A Rhizoctonia is constantly present in diseased roots, but its connection with the disease has not been established. The disease is very destructive and the infected plants die rapidly.

Sisal.—Anthracnose (*Colletotrichum agaves*) is frequently present and of considerable importance. Not previously reported from Porto Rico. Physiological disease (see p. 33).

Sorghum.—Rust (*Puccinia purpurea*). Smut (*Sphacelotheca sorghi*).

Sweet potato.—Java black rot (*Diplodia tubericola*) blackens the interior of roots, which lose weight, shrivel, and turn grayish, and finally black, covered with the fruiting bodies of the fungus. The disease appears occasionally at the station, but has not caused serious injury. White rust (*Albugo ipomoææ-panduranæ*) is commonly found, but does no serious damage. Leaf spot (*Cercospora* sp.) is of minor importance.

Swiss chard.—Leaf spot (*Cercospora beticola*) attacks the leaves during rainy weather and renders them worthless.

Tobacco.—Leaf spots (*Cercospora nicotianæ* and *Phyllosticta nicotiana*). *C. nicotianæ* was found on tobacco at the station, and *P. nicotiana* on leaves received from Corozal. Mosaic disease curls and mottles the leaves.

Tomato cultivation is successful only during the dry season. Bacterial wilt (*Bacterium solanacearum*) is the most serious disease in this region. Leaf mold (*Cladosporium fulvum*) causes the leaves to turn yellow and fall. The fungus is present on the under surfaces as an olive-colored mold. Spraying thoroughly with Bordeaux-mixture is efficacious in controlling the disease, except under conditions of extreme humidity. The disease ranks next to the bacterial wilt as a cause of loss. Blight (*Phytophthora infestans*) rarely causes loss here. In March an outbreak occurred among the station plantings. The weather was cool and rainy, and after a few days of warm, dry weather the disease disappeared. Leaf spot (*Septoria lycopersici*) was found at Garrochales, where it was confined generally to older leaves. Mosaic disease was severe at Garrochales. Infected plants were so mottled and dwarfed as to be worthless.

Vanilla.—Rot (*Glœosporium vanillæ*) attacks only vines which are in very shaded and moist situations and is negligible as compared with root disease. The disease is conspicuous and blackens and rots an occasional vine. Root disease (*Fusarium* sp.) is exceedingly destructive. (See p. 26.)

Watermelon.—Anthracnose (*Colletotrichum lagenarium*) is the greatest hindrance to watermelon growing. The crop is often planted in low, rich valleys where the humidity is high. Under such conditions the anthracnose fungus is difficult to control, even by frequent sprayings. Mycosphærella wilt (*M. citrullina*) is found occasionally. Covering the infected stems with earth has enabled most of the vines to mature their fruit.

Yam.—Leaf spot (*Cercospora carbonacea*).

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PORTO RICO AGRICULTURAL EXPERIMENT STATION
MAYAGUEZ, P. R.
Under the supervision of the
UNITED STATES DEPARTMENT OF AGRICULTURE

REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION

1926

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PORTO RICO AGRICULTURAL EXPERIMENT STATION, MAYAGUEZ

[Under the supervision of the Office of Experiment Stations, United States Department of Agriculture]

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REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION, 1926

CONTENTS

REPORT OF THE DIRECTOR

By D. W. MAY

The Porto Rico Agricultural Experiment Station is devoting its energies mainly to problems of research and agricultural production, especially now that extension, inspection, and farm-bureau activities have been taken over by other agencies. For many years following its inception the station found it necessary to do considerable pioneering work and to interpret the results of agricultural investigations and practices to the people of the island. These activities are now being carried on by agencies working in cooperation with the insular department of agriculture, and the station is free to deal with investigations of tropical research, the purpose for which it was primarily established.

The work of the several departments of the station is treated separately in this report. Efforts were again directed toward the solution of problems of feeding and breeding the cattle of the island, and comparisons were made of the results of crossing purebred sires with the native stock and the introduction of purebred animals of both sexes. New grasses were introduced for range improvement, and legumes giving promise of spreading over the island in the shortest period of time received special attention. Denuded areas were reforested with trees which will ultimately be profitable in themselves, and with leguminous nurse crops for coffee and fruit trees that are closely to follow them. Tests were made comparing the cost and value of nitrogen of legumes for cane soils with the cost and value of nitrogen in commercial fertilizers. Studies were continued to determine the critical factors governing pineapple production, and certain soils which formerly failed to yield are now in profitable bearing. The efforts of the station to promote the more general

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planting of both home and market gardens is showing results, and vegetables and flowers which were practically unknown in Porto Rico a few years ago are now appearing on the local markets. Investigations are being continued to determine the fertilizer, light, and heat requirements of flowers and vegetables from the temperate regions, and the insect and fungus pests attacking them.

With an increased price paid for coffee and a market consumption which bids fair to overtake the world's production, many of the local coffee growers are anxious to learn how to fertilize their trees to increase yields. To enable growers to use fertilizers economically and effectively, the station published during the year a bulletin giving the results of experiments covering a long series of years on local coffee soils.[1]

Corn from the temperate regions fails to prosper in the Tropics, and the native corn does not develop well. The station is endeavoring to produce good varieties by crossbreeding and by selecting from the native type. Both methods are showing promise.

The local sugar industry is receiving aid through the breeding of new varieties of canes of higher tonnage, greater sweetness, and resistance to disease and insect attack. During the year 150,000 seedlings were produced as the result of a study of the various methods of germination and propagation. This large production has increased the chances for selecting vigorous seedlings for further trial.

The West Indies have been repeatedly scourged by insect-borne diseases affecting man and beast. Some diseases, like yellow fever, have been exterminated, but others caused by the hookworm and the cattle tick prevail still in Porto Rico and entail a tremendous amount of suffering and heavy losses of life. The parasitologist has therefore very important work to do locally. During the year he made commendable progress in determining the presence of certain parasites and their life history and control.

Citrus scab, the most serious pest of the citrus industry at this time, is being combated mainly by an endeavor to breed a resistant variety of fruit. Coconut bud rot, which also attacks the hat palm, is being controlled by cutting and burning infected plants, and vanilla root rot by a series of experiments with soil disinfectants.

CATTLE

The livestock industry of Porto Rico has been benefited by the employment of improved methods of feeding and the introduction of judiciously selected purebred sires and high-grade dairy cows. Local dairymen, encouraged by the prevailing high price paid for milk, brought in a large number of dairy cows. The industry is still menaced by the cattle tick, and until this tick is brought under control the general stock farmer probably could more profitably build up his herd by means of a purebred bull rather than by acclimating animals of both sexes. Usually purebred cattle from the North can be carried through tick fever, but their vitality is considerably lowered by it, and they must be given a great deal of care if they are expected to prosper as the native cattle do. Purebred females may

[1] McCLELLAND, T. B. EXPERIMENTS WITH FERTILIZERS FOR COFFEE IN PORTO RICO. Porto Rico Agr. Expt. Sta. Bul. 31, 34 p., illus. 1926. Copies of this bulletin may be had by addressing the director of the station.

be brought in by the farmer who is prepared to give them good stabling and feed. Some of the animals may die, but their progeny will grow as vigorously as do the offspring of mixed breeding.

Some of the station herd, started with native cows crossed with purebred sires, now carry seven-eighths and others fifteen-sixteenths Guernsey blood. The four purebred Guernsey heifers which were introduced in 1923 were given the same treatment received by the crossbreds and yielded for the eight months of their lactation period an average of 3,235 pounds of milk. Two Shorthorn bulls and a heifer have been added to the station herd. These have heavier coats of hair and are harder to acclimate than the Guernseys, but, on the other hand, they put on flesh on grass and make heavier growth. The Shorthorns, when crossed with the native stock, also produce animals of better conformation and thicker flesh, and the milk yield is greatly increased.

The station bulls of both breeds are broken to work to give them needed exercise and keep them even tempered. The Guernsey sires become harder to manage with age, but the Shorthorns, like the native bulls, are better tempered and more easily handled. The success of the station in making purebred bulls work for their maintenance may lead planters to purchase purebred animals to replace some of the regular work animals in the cane fields.

FORAGE CROPS

Uba cane on all types of soil may not prove to be satisfactory for sugar production, but the crop is certain to be profitable as a stock feed. It is a very heavy yielder and usually produces more feed than any other forage crop tried at the station. Uba cane undoubtedly will be grown for forage once it is supplanted by superior seedling varieties for sugar.

Guatemala grass (*Tripsacum laxum*) is next in rank in point of yield. It is slightly sweet, and the whole stalk is relished by stock. The losses in feeding are low. Elephant grass (*Pennisetum purpureum*) returns large yields even on infertile soils and uplands. Under conditions of drought or overripening the grass soon becomes woody, which greatly increases the percentage of waste in feeding. Elephant grass should be cut more frequently than is the local practice. Guinea grass (*Panicum maximum*) and Para grass (*P. barbinode*), or malojillo, as it is known locally, are still grown on large areas. Guinea grass is preferable for the limestone soils of the semiarid regions, and the malojillo for soils which are heavy, swampy, and deficient in lime.

The average yield per acre of green forage for the five grasses, grown on similar soils at the station and cut at the beginning of the dry season as they were approaching maturity, was as follows: Uba cane, 54.7 tons; Guatemala grass, 35.4 tons; elephant grass, 32.6 tons; Guinea grass, 17.4 tons; and malojillo grass, 19.6 tons. The grasses were cut and fed whole, fed from racks above mangers, and cut in half-inch lengths and fed from troughs. The losses or uneaten percentages were as follows: Uba cane, 27.5 per cent whole, 13 per cent cut; Guatemala grass, 21 per cent whole, 18.5 per cent cut; elephant grass, 55 per cent whole, 50 per cent cut; Guinea grass, 27 per cent whole, 37 per cent cut; malojillo grass, 30 per cent whole, 26 per cent

cut. Estimated on the percentages consumed, the grasses yielded per acre as follows: Uba cane, 39.6 tons when fed whole and 47.6 tons fed cut; Guatemala grass, 28 tons fed whole and 28.9 tons fed cut; elephant grass, 14.7 tons fed whole and 16.3 tons fed cut; Guinea grass, 12.7 tons fed whole and 11 tons fed cut; and the malojillo, 13.7 tons fed whole and 14.5 tons fed cut. These yields are relative and would not be obtained from all lands or during all seasons. The grasses ratoon well and annual yields depend upon such factors as soil, rainfall, and the stage and frequency of cutting. Each planter may find two or more of the grasses more profitable than one, as his soils vary. All the grasses are worthy of trial.

The percentage of loss in feeding is least with the cut Uba cane. This is so sweet that the animals readily eat nearly all the stalk. The next lowest loss is with the Guatemala grass for the same reason.

FIG. 1.—Trough for feeding cut grass

The woody stem of the Guinea grass is discarded, and the animals separate the stalk and leaves best after the grass has been cut into short pieces. When the whole grass is fed the animals must consume the stems to get the leaves. For this reason a smaller percentage of the grass is consumed when it is fed cut than when it is fed whole. When the larger grasses are cut the animals eat all but the woody stems. The heavy losses in feeding elephant grass are due to its woody stems. Elephant, Guinea, and malojillo grasses should be fed when they are young and succulent. It has not been found profitable to run these grasses through a cutting box.

At the station grass for forage is run through a cutter set on a concrete floor. Thence the grass is pushed to an adjoining trough which is built on a lower level. (Fig. 1.) The trough is separated from the side on which the grass is cut by a woven-wire fence under which the grass is pushed to the animals feeding on the opposite side.

Java grass (*Polytrias praemorsa*), which is said to do well for pasturing animals in Java, was introduced into Porto Rico by the station some years ago and is doing very well. The grass grows readily from roots and makes a thick mat of both leaves and roots, and seeds profusely. It is hardy, better adapted to lawns than any other grass under test, and crowds out the native grasses. Java grass turns brown under conditions of prolonged drought but does not die out. The leaves have a remarkable water-holding capacity, and drops of rain or dew remain in their folds for some time after the sun strikes them. This fact undoubtedly helps to keep the grass green after other varieties have dried. The grass is considered to be of value for upland pastures and hillsides and is readily grazed by cattle.

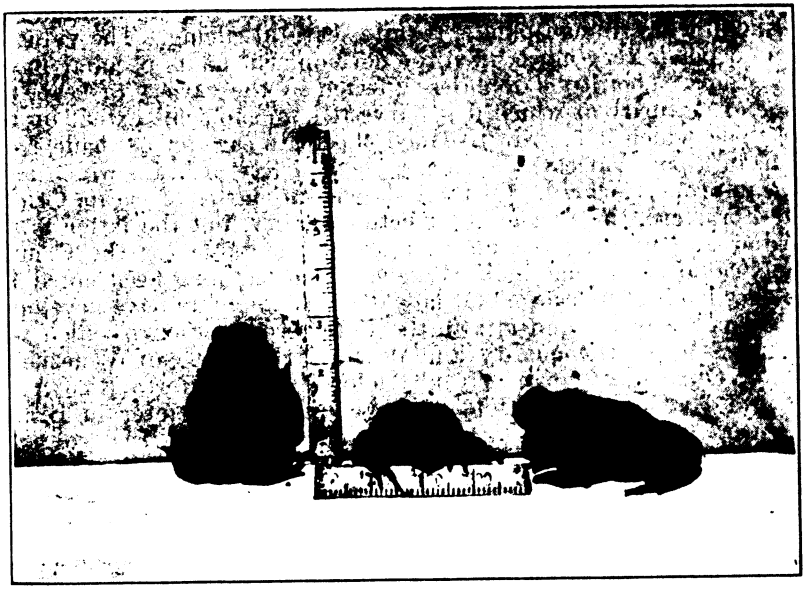

FIG. 2.—Giant Surinam toad (*Bufo marinus*)

SURINAM TOAD

In 1920 some giant toads (*Bufo marinus*) were introduced into Porto Rico from Barbados. (Fig. 2.) These were liberated at the station and increased so rapidly that now they are found in great numbers in the western end of the island. The toads are being shipped in 1 dozen to 10 dozen lots to other parts of the island. Planters in this part of the island report lessened depredations of the changa (*Scapteriscus vicinus*) and white grubs (*Phyllophaga* spp.) as the probable result of the introduction. The toad is nocturnal in habit and burrows in the ground during the day. Four kinds of night-feeding invertebrates, the May beetles and their white grubs, slugs or snails, the changa or mole cricket, and cockroaches are especially destructive in Porto Rico. In other countries these pests are apparently held in check by natural enemies. The toad

promises to be of value for combating insect pests which have few natural enemies.

An examination of the stomachs of the *Bufo marinus* found near the station disclosed the presence of ants of various kinds; May beetles (*Phyllophaga* spp. and *Lachnosterna citri*) and grub of the latter; *Zophobas morio* and small weevils; cockroaches, three species; flea beetles, *Systena basalis* and *Cerotoma ruficornis;* melon beetle, *Diabrotica* sp.; Hemiptera partly digested and leaf hoppers; changa or mole cricket (*Scapteriscus vicinus*); red, black, and yellow millipedes; housefly pupæ; centipedes; large Diptera (tabanid); land-snail shells, *Drymaeus liliaceus;* and lepidopterous caterpillars.

CACAO CURING

Marketable cacao, like some other plants carrying an alkaloid and relished by the human palate, requires careful curing. The value of cacao depends very much upon the development of its peculiar flavor and aroma. Quality is doubtless affected by the variety of bean, the stage of maturity at which it is harvested, and to some extent by the soil upon which it is grown. Good chocolate can not be made from beans of a poor variety, nor from a good variety of beans which have been improperly cured. Of the two general classes of cacao, Criollo and Forastero, the former is of better quality, but the latter is the hardier and grows on lands that are not suitable for the Criollo. The Criollo is at home in Venezuela, which has long been noted for the excellence of its cacao. Of late years the planters have developed a tendency to grow and mix in the Forastero, a practice which will doubtless lower the quality and decrease the value of Venezuelan cacao. Oscar Loew, formerly physiologist of the Porto Rico Agricultural Experiment Station, who spent the past winter in Brazil, in a personal letter reports as follows on the cacao of that country:

There are 15 varieties known, while only 3 are generally grown. Criollo is the best variety, but certain hybrids are grown to a greater extent because of higher yields and on less fertile lands. The product of the Forastero cacao never reaches the fine quality of the Criollo, which by reason of its excellent aroma and uniformity brings the highest price in commerce. The Criollo has a higher percentage, 55 per cent, of fat than other varieties and requires a shorter time in preparation for market. The consumption of cacao in Brazil is low and the best qualities found there as manufactured are imported. Four fungus diseases of cacao in Brazil are noted, while depredations by animals are frequent. As to methods for bettering the product, the question of variety comes first and the Criollo is recommended. The lessened production might be overcome by higher prices paid for the better product.

Careful preparation of the bean has much to do with the quality, and fermentation with the development of the aroma, of the best cacao. Fermentation should be finished before the adhering pulp of the bean is changed through alcoholic and acetic fermentation.

After the husk has been discarded in the drying process the pulp surrounding the bean must be removed. Probably the easiest way to remove the pulp is to let it ferment and slough off. During this time changes are occurring in the bean. This is the so-called fermentation process of cacao and varies in different cacao-producing countries. The quality of the bean is thought to be affected and the aroma developed by alcoholic followed by acetic fermentation of the pulp, but results of experiments at the station show that these

changes take place in the bean by the action of unorganized ferments or enzymes. The cacao bean is very rich in enzymes, as is shown by the characteristic changes rapidly taking place in the color of the tissues of freshly cut ripe beans. The action of the enzymes within the bean undoubtedly is favored by temperature and other factors. The inner husk of the cacao pod and the pulp surrounding the bean fail to ferment sufficiently to develop the characteristic aroma of cacao, but by sealing the bean they evidently enable it to develop the characteristic flavor.

Fermentation may begin in the fully ripe bean before the pod is broken, and the seed sprouts after a time. The quality of the product of such overripe beans is poor.

The alcoholic and acetic fermentation of the pulp facilitates cleansing of the beans preparatory to drying, but it does not improve their general quality. The undesirable sour odor emanating from the dried bean is caused by the acidity which develops during the later stages of fermentation. The quality of the fermented bean failed to improve in experiments using cultures of yeast, acetic, lactic, and Bulgaric acid-forming bacteria. When lactic acid bacteria were used the color of the beans improved, turning brighter, and the beans were plumper, but their quality was lowered. When dilute acids were used the flavor of the beans failed to improve and the action of the enzymes was retarded or stopped.

The best cacao comes only from thoroughly ripe beans which have been dried at sufficiently low temperatures to prevent destruction of the enzymes. If the beans are stored while they are too moist they will mold; and, on the other hand, if the beans are stored after they have become too dry they will not ferment. Stored cacao under proper moisture conditions continues to improve over a period of some months. In Venezuela the beans are coated with clay to improve their quality. This improvement can not be attributed to any added element from the clay, but is due to the sealing process, which enables the beans to retain their aroma and ferment uniformly. Coatings of brick dust and natural lime (coral) were found to have a favorable influence on the beans, but were not nearly so satisfactory as coatings of clay.

Certain salts were found to exert a favorable influence in the curing of cacao. They enable the beans to retain an increased percentage of water and thus aid the extended curing or fermentation process. They also prevent souring in the fermenting pulp and combine with the pulp in forming a coating which facilitates changes, developing the best consistency and flavor. The beans were soaked one to three days in 5 per cent solutions of the salts. The solutions having a favorable influence on flavor were, in the order of their merit, potassium alum, calcium chloride, magnesium chloride, ammonium alum, sodium chloride, and ammonium sulphate. Treating the beans with the salt solutions to some extent prevented them from shrinking and brightened their color.

NOTES ON GARDENING

The scarcity of fresh vegetables in the dietary of the people of Porto Rico is a matter of concern, more especially since climatic conditions in nearly all parts of the island are favorable for gardening.

The export of winter vegetables, notably peppers and tomatoes, to the markets of the mainland is growing, but on the whole the island continues to import vegetables throughout the year, and the people depend too much upon dried and canned foods.

The first requisite for successful gardening is good soil. Land which has been devoted to field crops for some years can not be used for garden purposes until the soil has been fertilized and given some organic matter to increase its humus content. In the Temperate Zone winter cleans the ground, and freezing mellows it. In the Tropics, on the other hand, where there are alternate wet and dry seasons, the ground puddles and becomes so hard and compact as to be almost impossible to cultivate. Before such ground is devoted to truck crops it should be planted with cover crops to prevent surface washing, smother out weed and other volunteer growth, and enrich and shade the soil. Rotted manure is the best fertilizer for the garden, but commercial fertilizers also can be used to advantage. Occasionally such fertilizing materials as tobacco stems and wood ashes can be obtained at low cost and often for the hauling. Lime should be used as a corrective for acid soils.

By growing his vegetables and flowers quickly the planter may bring them through without insect or fungus attack. However, he should be prepared to deal with such pests when they appear. The following notes on vegetables and flowers are based on the results of experiments covering many years at the station and may be of interest to prospective growers:

VEGETABLES

Among the vegetables that should occupy an important place in the dietary are the leafy kinds, including lettuce, cabbage, spinach, and the like.

Lettuce grows readily at all seasons. The seed should be sown in boxes and the resulting young plants transplanted to the open. Lettuce does not always head under local conditions and soon starts to form a seed stem. Varieties producing the most leaf in the shortest time are desirable for Porto Rico. The Mignonette seems to be well adapted for home use.

Swiss chard is a very suitable vegetable for salad making. Beetles often destroy the leaves, and, since they constitute the edible part, it is not practicable to spray the plant with poisons. Nicotine sulphate has given good results at the station when used to combat the insects.

Mustard, collards, and spinach thrive and should be eaten before they grow coarse and fibrous. These salad plants do not have the flavor characteristic of similar plants in the temperate region. Successive plantings are recommended.

Cabbage grows well but does not form as firm heads as in colder countries. Reckoned in pounds, cabbage can be imported more cheaply than it can be grown locally.

Cauliflower seldom heads in Porto Rico. Kohlrabi, a good substitute for cauliflower, is easily grown and usually is of excellent quality. It should be better known locally than is the case. Okra grows well throughout the year and sometimes during periods of heavy rains at Mayaguez it is the only vegetable available.

All kinds of peppers do well. The pepper is one of the few vegetables now being grown for the markets of the mainland. Both native and improved varieties of eggplant are easily grown.

Celery is easily grown. It should be started in boxes and later the seedlings should be transplanted to the open. Celery is not so hard or crisp as in cold climates.

Radishes are at home in Porto Rico. Carrots need care while the plants are small and tender. Turnips should be grown quickly; else they will be woody and bitter. Beets should be transplanted for best results and the tops dusted or sprayed with poison to safeguard them from insect attack.

Melons are likely to be attacked by insect and fungus pests and should be grown in a different location in the garden each year. The poor quality of most of the native melons is due to the fact that the vine is attacked by disease, or harvesting is done before the melons have a chance to ripen. Melon varieties vary considerably in their ability to withstand fungus attack.

Onions do well when they are grown on suitable soil. They are grown to some extent commercially, though more and more are imported each year. Seasonal differences must be taken into consideration when onions are grown. They develop their largest bulbs during the summer or when the daylight is longest.

Peas do so well that one wonders why they are so seldom sown. Evidently they have never been grown to any extent, for the soils fail to show the presence of the proper nitrogen-storing bacteria. Pea seed should be inoculated with nitrogen-fixing bacteria when sown for the first time.[2] All types of peas tested at the station were successful. The low-growing varieties are the quickest to bear, but they bear for a short time. The tall-growing kinds, those that grow 5 to 6 feet tall, bear during a period of four to six weeks, and produce more abundantly than do the low-growing peas. Staking costs are more than compensated for by increased yields.

The tomato is a tropical plant. The fruits of a wild variety which is found growing along the river courses are small and wrinkled and used to flavor soups. The improved large, smooth variety should be found growing in every local garden. The introduced tomato is not so immune to disease as is the wild kind, but can be successfully grown. Varieties vary in vigor and immunity. Grown on the proper soil the fruits equal in size, form, and flavor those produced elsewhere. The progeny of crosses between native and improved varieties have shown some immunity to disease, but in smoothness of skin and in flavor the fruits do not compare with the improved kinds. Soils for tomatoes should not be too rich in nitrogen; else the plants will run to vines. The plants should be pruned when necessary and grown in rotation with other crops. Better still, the plants should be grown on different plats of land each year. Diseased leaves and plants should be removed from the plat.

FLOWERS

The balsam, one of the easiest flowers to grow in Porto Rico, grows 6 inches high, blooms, and seeds in the short days of winter, and

[2] Inoculation material and directions for applying it may be obtained from the station.

attains a height of 12 inches, but requires more time to reach maturity, in the long days of summer. The balsam can be used as a house plant for a few days after flowering, provided it is properly taken up and potted. The sweet pea is affected by the length of day. Superb sweet peas, such as are to be found in the States, grow but fail to bloom. The so-called winter-flowering kinds that have been developed from a tropical variety are recommended for use as ornamentals. Sweet-pea seed should be grown in inoculated soil. The zinnia thrives throughout the year and on most soils. It makes its rankest growth during the period of longest days. Handsome and varied types have been bred from this old-fashioned flower. The seeds of the snapdragon are small and should be started in boxes and the resulting young plants transplanted to the open. Snapdragons are in many colors and bloom through a long season. Calendulas do well, and the cut flowers last for some days. Phlox, candytuft, and verbena make satisfactory border plants. Larkspur blossoms sparingly. The petunia is difficult to get started, then grows well and blooms over a long period. Nasturtiums do well and bloom profusely. Sunflowers make rank growth and some of the double varieties are very attractive as ornamentals. Begonias thrive and can be easily propagated from leaf cuttings. The seed are rather small and must be given tender care if they are expected to germinate. Coreopsis and gypsophila make satisfactory garden plants. Asters bloom sparingly, and the flowers are small. Coleus makes splendid growth in shaded situations, but is more highly colored when grown in the sun. Coxcomb and hollyhock make rank growth and produce many flowers. The dahlia grows well in most situations. With a 12-month growing season in Porto Rico the grower should be able to develop many new and attractive types of flowers.

REPORT OF THE ASSISTANT CHEMIST

By J. O. Carrero

MANAGEMENT OF CANE SOILS

Studies of nitrogen utilization by cane soils were continued, and the fourth crop, a first ratoon of the Kavangire variety, which was grown under conditions described in former reports, was cut early in the year. Data were recorded on crop yields of the different plats. The work of the year was mainly of an analytical nature. Chemical analyses were made of part of the samples taken during 1925, as well as of those taken in 1926. Samples of juice were analyzed for sucrose content, purity, and quantity of fertilizing elements. Ground samples of the straw, trash, and bagasse were examined to learn the amount and kind of fertilizing elements they removed from the soil, and soil samples from the various plats were analyzed to determine what changes took place in composition as the result of treatment.

Progress in the work was hampered by reason of the nature of some of the material to be analyzed. Cane leaves and bagasse were easily handled, but cane juice had to be analyzed for its nitrogen, phosphoric acid, potash, lime, and magnesia content. Considerable difficulty was experienced during evaporation of the juice and ashing of the residues, owing to lack of the necessary laboratory equipment

to carry on the work. Three methods were tried to overcome the difficulty: (1) The juice was evaporated with concentrated sulphuric and nitric acids; (2) the juice was evaporated with concentrated nitric acid; and (3) measured quantities of the juice were allowed to ferment for 14 to 21 days, when the alcohol produced was evaporated, and the solution again made up to volume to ferment a second time for two weeks. Nearly all of the organic matter present was thus destroyed; then the solution was evaporated nearly to dryness, when 40 c. c. of concentrated nitric acid was added and boiling was maintained for half an hour.

The first method was tried only once, since it necessitated the use of too large quantities of nitric and sulphuric acids to destroy the large amount of sugar and organic matter present in the 250 c. c. sample portions of juice. The second method gave good results, but also required excessive quantities of nitric acid to destroy the sugar present in the juice. It was then decided to destroy most of the sugar present by fermentation. Accordingly, 250 c. c. sample portions of juice were inoculated with a pure yeast culture and allowed to ferment two to three weeks before being evaporated nearly to dryness. The original volume was restored by adding pure distilled water, and the sample was again inoculated with yeast culture. Fermentation was allowed for two to three weeks before it was again evaporated to dryness, and 25 to 40 c. c. of concentrated nitric acid was added, and boiling was maintained for half an hour. This treatment destroyed most of the sugar and organic matter present in the juice, and the small amount remaining was burnt off after the added acid had evaporated. This method was tested both with a juice sample and with a carefully prepared solution.

Eight samples of juice were analyzed for phosphoric acid by the method described and by evaporation and burning with magnesium nitrate. Samples 1 to 4, inclusive, were tested by evaporation and burning with magnesium nitrate and found to contain 82.4 to 82.8 mgm. of phosphoric acid per 100 c. c. of juice, or an average of 82.55 mgm. Samples 5 to 8, inclusive, were tested by the method under discussion and found to contain 82.4 to 82.6 mgm. of phosphoric acid per 100 c. c. of juice, or an average of 82.5 mgm.

The prepared solution had the following composition: Pure sucrose 16 gm., phosphoric anhydride 85 mgm., potassium oxide 150 mgm., calcium oxide 14 mgm., and magnesium oxide 18 mgm. per 100 c. c. of juice. A series of solutions were prepared by both methods and analyzed for phosphoric acid and for potash. Phosphoric acid determination was made in samples 1 to 4, inclusive, by evaporation and burning with magnesium nitrate, and in samples 5 to 8, inclusive, by the method under trial. The samples were found to contain 84.4 to 84.6 mgm. of phosphoric acid per 100 c. c. of juice. Samples 5 to 8, inclusive, as prepared for the phosphoric acid determination, was found to contain 149.4 to 149.7 mgm. of potash per 100 c. c. of juice. Apparently loss of phosphoric acid or potash did not occur during preparation for analysis, since the true content of the original solution was 85 mgm. of phosphoric acid and 150 mgm. of potash.

The next difficulty met with was in the determination of lime. The juice is low, especially in calcium oxide, which ranges from 10

to 16 mgm. per 100 c. c. of juice. The ordinary methods failing to give concordant results, recourse was had to other methods. Through the kindness of W. H. Ross, C. B. Durgin, and R. M. Jones,[3] G. E. F. Lundell and J. I. Hoffman,[4] and F. H. McCrudden[5] their methods were tried with cane-juice samples as prepared by the proposed fermentation method.

Four samples of juice, which were tested for calcium content by the Ross method, were found to contain 0.0167 to 0.0168 gm., or an average of 0.01675 gm. per 100 c. c. of juice; four others, tested by the Lundell method, had 0.0171 to 0.0172 gm., or an average of 0.01715 gm. per 100 c. c. of juice; and a third series of four, tested by the McCrudden method, had 0.0168 to 0.0172 gm., or an average of 0.0171 gm. per 100 c. c. of juice. The three methods gave closely concordant results so that they could be used indiscriminately. However, since the Ross method requires the use of 95 per cent alcohol, which is difficult to obtain, the other two methods were adopted for use.

The nitrogen content of the leaves, trash, and bagasse was readily determined, but there was some doubt as to the application of the method to the juice. Accordingly, tests were made on samples of juice, varying the conditions of analysis to learn the effect on results. Samples were tested immediately after expression of the juice. Some were preserved by the addition of 10 c. c. of concentrated sulphuric acid and tightly stoppered; and others were allowed to ferment naturally both without and after the addition of distilled water equaling in volume the sample taken. The same tests were made on samples receiving a small amount of nitrogen in the form of ammonium sulphate.

The nitrogen content in milligrams per 100 c. c. of juice is shown in the following series of 25 c. c. sample portions:

Samples 1 to 4, inclusive, to which nitrogen was added immediately in the fresh sample, had 25.96 to 26.56 mgm., or an average of 26.1 mgm. of nitrogen. Samples 5 to 8, inclusive, each of which was preserved by the addition of 10 c. c. of concentrated sulphuric acid, then stoppered and not analyzed for 20 days, had 25.96 to 26.24 mgm., or an average of 26.1 mgm. Samples 9 to 12, inclusive, were allowed to ferment for 10 days before being analyzed. Sample 12 was lost. The solutions emitted a slightly acetic odor and contained 26.24 mgm. of nitrogen. Samples 13 to 16, inclusive, each of which was diluted with 25 c. c. of distilled water and allowed to ferment for 10 days before being analyzed, had 25.68 to 28.48 mgm., or an average of 25.77 mgm. of nitrogen. Sample 15 was not included in the average. Samples 17 to 20, inclusive, were allowed to ferment for 20 days before being analyzed and were found to contain 25.96 to 26.24 mgm., or an average of 26.15 mgm. of nitrogen. The solutions emitted an acetic odor. Sample 20 was lost. Samples 21 to 24, inclusive, each of which was diluted to 50 c. c. with distilled water and allowed to ferment for 20 days before being analyzed had 25.4 to 26.24 mgm., or an average of 25.68 mgm. of nitrogen.

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[3] ROSS, W. H., DURGIN, C. B., and JONES, R. M. THE COMPOSITION OF COMMERCIAL PHOSPHORIC ACID. Jour. Indus. and Engin. Chem. 14: 533–535. 1922.

[4] LUNDELL, G. E. F., and HOFFMAN, J. I. THE ANALYSIS OF PHOSPHATE ROCK. Jour. Assoc. Off. Agr. Chem. 8: 184–206. 1924.

[5] MCCRUDDEN, F. H. THE QUANTITATIVE SEPARATION OF CALCIUM AND MAGNESIUM IN THE PRESENCE OF PHOSPHATES AND SMALL AMOUNTS OF IRON DEVISED ESPECIALLY FOR THE ANALYSIS OF FOODS, URINE, AND FECES. Jour. Biol. Chem. 7: 83–100. 1910.

Fermentation not only destroyed part of the sugar in the juice and left less organic matter to be oxidized by sulphuric acid, but it also permitted some of the samples pressed on one day to be analyzed on later days. This fact suggested the use of larger sample portions than 25 c. c. of juice.

In the following series 50 c. c. portions were analyzed for nitrogen in milligrams per 100 c. c. of juice:

Samples 25 to 28, inclusive, which were allowed to ferment for 10 days before being analyzed, emitted a slightly acetic odor. They were found to contain 25.16 to 26.16 mgm. or an average of 25.27 mgm. of nitrogen. Samples 29 to 32, inclusive, were each diluted to 75 c. c. with distilled water and allowed to ferment for 10 days before being analyzed. They had 25.3 to 26.56 mgm., or an average of 25.86 mgm of nitrogen. Sample 32 was lost. Samples 33 to 36, inclusive, the undiluted juice of which was allowed to ferment for 20 days before being analyzed, had 25.3 to 26 mgm., or an average of 25.58 mgm. of nitrogen, and emitted a strong acetic odor. Samples 37 to 40, inclusive, were each diluted to 75 c. c. with distilled water and allowed to ferment for 20 days before being analyzed. They were found to contain 25.16 to 25.72 mgm., or an average of 25.44 mgm. of nitrogen, and emitted a strong acetic odor. Samples 41 to 44, inclusive, were each diluted to 75 c. c. with distilled water and allowed to ferment for 20 days before being analyzed. They had 25.3 to 25.58 mgm. or an average of 25.44 mgm. of nitrogen and emitted a strong acetic odor.

In the following series, 25 c. c. sample portions of juice were run for nitrogen in milligrams per 100 c. c. of juice, but the conditions were changed by the addition of small amounts of nitrogen in the form of ammonium sulphate.

Samples 1 to 4, inclusive, were analyzed immediately after being expressed and were found to contain 20.2 to 20.4 mgm., or an average of 20.35 mgm. of nitrogen. Samples 5 to 8, inclusive, each of which received 20 mgm. of nitrogen as ammonium sulphate and was analyzed at once, had 20.2 mgm. Samples 9 to 12, inclusive, each of which received 10 c. c. of concentrated sulphuric acid, was tightly stoppered and analyzed 20 days later, had 20.2 to 20.8 mgm. or an average of 20.45 mgm. of nitrogen. Samples 13 to 16, inclusive, each of which received 20 mgm. of nitrogen as ammonium sulphate, was preserved by the addition of 10 c. c. of concentrated sulphuric acid and analyzed 20 days later, had 20.2 to 20.4 mgm. or an average of 20.27 mgm. of nitrogen. Sample 13 was lost. Samples 17 to 20, inclusive, the undiluted juice of which was allowed to ferment for 10 days before being analyzed, had 20.4 to 21.6 mgm., or an average of 20.95 mgm. Samples 21 to 24, inclusive, each of which was twice diluted to 50 c. c. with distilled water and allowed to ferment for 10 days before being analyzed, had 20.8 to 21.6 mgm., or an average of 21.2 mgm. Samples 23 and 24 were lost.

Fermentation of undiluted and diluted samples before analyzing them is more advantageous than determination of the fresh juice and the juice preserved with 10 c. c. of concentrated sulphuric acid in requiring 10 to 20 c. c. less of concentrated sulphuric acid to destroy the organic matter present. Fermentation also requires about 40 to 60 minutes less for oxidation than do the other two

methods. Undiluted fermented samples yielded results which were comparable with those of fresh-juice samples; the results of diluted samples were inclined to be low. The advantage gained by fermentation was lost, however, when 50 c. c. portions of juice were used instead of 25 c. c. portions. Notwithstanding fermentation, enough sugar remained in the solution to require a longer time for digestion than was required by the unfermented sample; and a loss of nitrogen occurred which, though small, was high in proportion to the total amount present. The same differences were observed when the samples received a small amount of nitrogen in the form of ammonium sulphate. Closely concordant results were obtained between samples of the fresh juice both with and without ammonium sulphate and samples with and without the addition of ammonium sulphate but preserved by the addition of 10 c. c. of sulphuric acid.

A consideration of the results led to the final adoption of the following methods: 25 c. c. sample portions of juice were preserved by the addition of 10 c. c. of concentrated sulphuric acid. The oxidation of the organic matter was carried on later by the addition of 25 to 35 c. c. of sulphuric acid, 15 gm. of anhydrous sodium sulphate, and 0.2 gm. of copper sulphate.

For phosphoric acid, potash, lime, and magnesia, 300 c. c. of juice was placed in a 500 c. c. Erlenmeyer flask and fermented with pure yeast culture for 15 to 20 days, when the solution was evaporated nearly to dryness. Two hundred cubic centimeters of distilled water was added and the solution again inoculated with the yeast culture. Fermentation was allowed for 15 days, when the solution was again evaporated nearly to dryness. Upon the addition of 40 to 50 c. c. of concentrated nitric acid to the solution a strong oxidation took place of whatever sugar and organic matter remained. Very little heat was required to obtain a white ash when the solution was evaporated to dryness on a porcelain evaporating dish. The ash was dissolved in hydrochloric acid and made up to its original volume. The volumetric method recommended by the Association of Official Agricultural Chemists[6] was used by phosphoric acid determination. Potash was determined by the Lindo-Gladding method and lime and magnesia by the McCrudden method or the Lundell and Hoffman method indiscriminately. Nitrogen was determined in the fresh sample when possible, or else 25 c. c. sample portions of the juice were preserved with 10 c. c. of concentrated sulphuric acid and tightly stoppered, to be analyzed at a later date.

REPORT OF THE HORTICULTURIST

By T. B. McClelland

PHOTOPERIODISM

Studies of photoperiodism of beans and sweet potatoes were continued. The work has been amplified to include onions and pineapples. Plantings were made at intervals of four weeks or longer.

[6] Association of Official Agricultural Chemists. Official and tentative methods of analysis. As compiled by the committee on revision of methods. Revised to Nov. 1, 1919. 417 p., illus. Washington, D. C. 1920.

Two different treatments were given. The plants in the short-day group were brought from a darkened room 11 hours prior to sunset; for the plants in the long-day group the daily light period was prolonged to 13½ hours after sunrise by means of electric lights.[7] These two periods correspond approximately to December and June day lengths at this latitude, 18° N. A third group was grown under normal light exposure.

Growth and production of beans were markedly affected by many factors other than length of light exposure. In some plantings all groups did well and in others all did poorly. Notwithstanding this variation, the favorable influence of a long light exposure on growth was very consistently shown, since in 18 of 20 plantings of the Porto Rican white bean the average height under the long day was greater than that under either the normal or the short day. The difference in height between the long and the short day groups of the 20 plantings was 45 per cent. The Porto Rican red bean is strictly a bush variety, whereas the Porto Rican white variety, under favorable conditions and a long light exposure, develops a long, twining vine. The red variety, however, responded similarly to the longer light exposure, though to a less pronounced degree. In 18 of the 20 plantings the average height of the long-day group exceeded that of the short-day group and in 19 instances that of the normal-day group also. A difference of 18 per cent was noted in height between the long and the short day groups of the 20 plantings.

Figure 3 shows the comparative differences in development at one month from planting under the three light exposures, the short-day group at the left, the long-day group at the right, and in the center the group receiving the normal light exposure from July 29 to August 29. In this planting the long-day group blossomed one day earlier than the normal-day group, which, in turn, blossomed one day earlier than the short-day group. Of 18 comparative plantings of the Valentine variety, the long-day group exceeded in average height the short-day group in 14 instances and the normal-day group in every instance. The difference between the long and the short day groups of the 18 plantings was 16 per cent. The evidence as to the comparative effect of these periods of illumination on seed production was inconclusive. In all groups both very poor and very good yields were obtained.

The production of the sweet-potato varieties Key West and Porto Rico was not shown to be correlated with the light periods tested.

Onions were very sensitive to limited variation in length of daily light exposure. The varieties tested included White Bermuda, Prizetaker, Yellow Globe Danvers, and Silver King (Giant White Tripoli). The reaction of the White Bermuda to the differences in day length was very pronounced. In Figure 4 the plants in the two containers at the left, grown under the short daily light exposure, were still in the spring-onion stage, whereas their contemporaries in the two central containers, grown under a normal light exposure (November and December, respectively, to May), developed good bulbs, as did also the plants shown in the two containers at the right, grown under

[7] Fifty-watt Mazda blue "daylight" bulbs were used; five of these were set 2½ feet apart in a line. The distance from the electric-light bulb to the soil surface where plants were grown was not over 5 feet at any point.

FIG. 3.—Porto Rican red beans planted July 29 and photographed August 29. Center, group receiving normal light exposure; left, a slightly shorter than normal exposure; and right, an artificially protracted exposure, the two latter periods corresponding approximately to December and June day lengths at this latitude

FIG. 4.—Reaction of White Bermuda onions to daily light exposures. Right, corresponding approximately to June day lengths; and left, to December day lengths at 18° N. latitude. From left to right, containers 1, 3, and 5 were planted November 14, and the others December 12. Photographed May 1. Plants in the center containers received the normal light exposure

the long daily light exposure. The tops of most of the plants in the two latter groups had fallen over, an indication of approaching maturity. The plants rarely got beyond the spring-onion stage under the short light exposure. In one lot such plants as remained alive at 60 weeks were still in the spring-onion stage.

Figure 5 shows the development 244 days after planting, of the plants from the second, fourth, and sixth containers from the left in Figure 4. This shows that while White Bermuda onions may be planted for spring onions at any time of the year, bulbs will rarely be formed except during the season of longer days.

The Prizetaker, known for its large bulb formation in temperate regions, remained in the spring-onion stage under the short-light

FIG. 5.—White Bermuda onions as affected by varying lengths of daily light exposure. Planted December 12 and photographed June 4. Center, grown under normal light exposure; left and right, under light exposures corresponding to December and June day lengths, respectively, at this latitude

exposure. The majority of the plants of this variety, under the normal and the longer exposures, remained in the spring-onion stage, although some were intermediate and a small percentage developed bulbs. Their condition 140 and 168 days after planting is shown in Figure 6, the short, normal, and long day groups appearing from left to right. The vigorous leaf development and the somewhat swollen bases in lieu of typical bulb formation 244 days after planting may be seen in Figure 7, the sequence as before.

Yellow Globe Danvers showed comparatively slight difference in development in the three groups, all remaining in or progressing slightly beyond the spring-onion stage. This variety 245 days after planting is shown in Figure 8.

FIG. 6.—Prizetaker onions 140 and 168 days after planting, with vigorous top growth but no bulb formation. Left, short light exposure; center, normal; and right, long light exposure

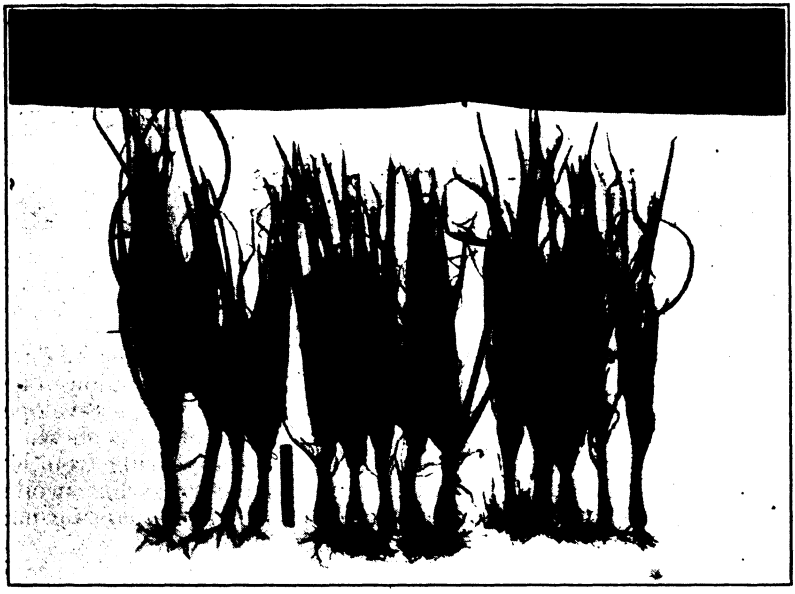

FIG. 7.—Prizetaker onions 244 days after planting (October 17 to June 18). Note the absence of typical bulb formation. Left, grown under light exposures corresponding in length to December; right, to June days at this latitude; and center, under normal light exposure

The behavior of the variety showed that it is wholly unsuited for this low latitude.

Silver King (Giant White Tripoli) under a short daily light exposure developed only to the spring-onion stage, one lot 400 days after planting being still spring onions in form. Some of the plants in the normal and long day groups when harvested 175 to 245 days after planting had developed bulbs, but others had not progressed beyond the spring-onion stage.

This work has shown that at this latitude it is useless to plant certain varieties well known for their good qualities in higher latitudes, as they will not form bulbs under these shorter light exposures. Others will form bulbs at the season of longer days only, and this fact must be taken into consideration in planting.

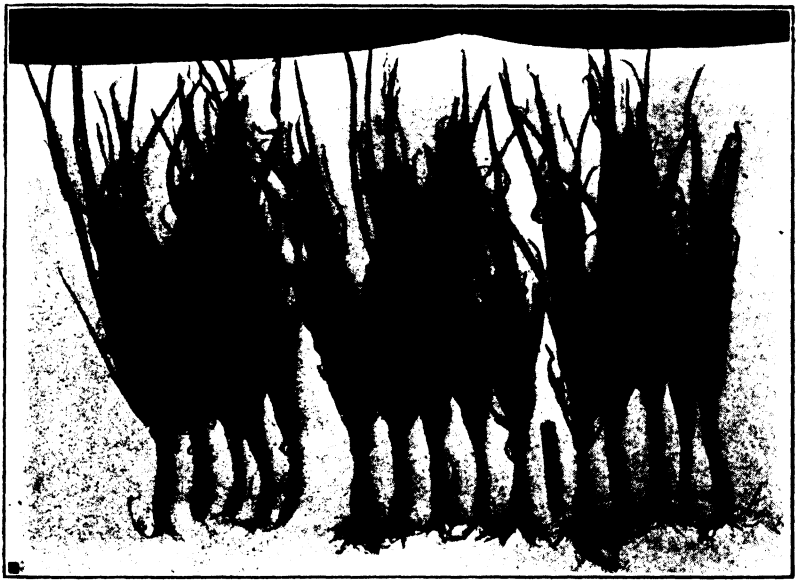

FIG. 8.—Yellow Globe Danvers onions 245 days after planting. Note the absence of typical bulb formation. Left, grown under light exposures corresponding to December; center, normal exposure October 17 to June 19; and right, to June day lengths at this latitude

In August, 10 Red Spanish pineapple slips were planted in each group. Measurements of the longest leaf on each plant 3, 6, and 9 months after planting, as an index of growth, showed an average difference between groups never greater than 1.6 inches. In May the flush indicative of the approach of blossoming was observed in some individuals in both the short and the normal day groups but was not seen in the long-day group until July. The longer daily light exposure appeared to have retarded the blossoming stage, though the blossoming of the groups overlapped. Further evidence on this point is desirable.

COFFEE

The fertilizer tests with coffee were continued. To provide for further work along this line an extensive coffee planting has been

made in units or plats of 10 trees each, ditches separating each plat from those adjoining. The performance of the plats will be recorded prior to applying fertilizer to learn whether or not they are lacking in uniformity. As the field selected was unshaded and protection against the sun was necessary, the newly transplanted seedlings were at first shaded by a section of coconut leaf set in the ground near each. To furnish a more lasting shade, *Crotalaria juncea*, *C. striata*, and *Tephrosia candida* were planted throughout, and cuttings of *Gliricidia sepium* and *Erythrina berteroana* were closely set. Within six months the shade had become so dense in places as to require thinning, and from then on periodic thinning or lopping. One year after planting many Gliricidias had grown as much as 12 feet (fig. 9) and this mixed shade was considered as having proved to be highly satisfactory. As growth warrants, all save the Gliricidias will be

FIG. 9.—Growth made by young mixed shade for coffee within a year after planting. *Gliricidia sepium*, *Erythrina berteroana*, *Tephrosia candida*, and *Crotalaria* spp.

removed, the latter being left as permanent shade trees. Cuttings of *Erythrina berteroana* are recommended for use where shade must be rapidly developed, four or five being placed in tent fashion around the small coffee trees to be shaded and other cuttings at greater distances from them.

Yields from the 40 plats under test fell little short of those of last season, and continued to demonstrate the value of potash in fertilizer applications to coffee. Contrasting the plats according to the kind of fertilizer applied, it was found that each group which had received potash either singly or in combination exceeded the check in yield, whereas the other three groups receiving nitrogen, acid phosphate, and the two in combination, respectively, but no potash, fell below the check. Of the 15 plats of highest yield, all but 2 had received potash, while 6 had received no nitrogen, and 9

no acid phosphate. The plat receiving the maximum application of nitrogen and potash in combination had averaged per tree for the two preceding years a production equivalent to 2 pounds 15 ounces and 2 pounds 13 ounces of dried coffee beans, parchment removed, but produced this year 3 pounds 2 ounces per tree.

The experimental plats on the López plantation at Las Vegas are showing some interesting results from fertilization. The present fertilizer treatments were begun in 1920. Production records from 1916 to 1920 showed that the check plat was not inferior to the fertilized plats. The total yield of the check for the five-year period, 1921–1925, raised to acre rates, was 606 pounds, whereas an average of 1,380 pounds was produced by the fertilized plats. This amounted to an annual increase of 155 pounds of coffee per acre. In 1925 the check plat yielded at the rate of 100 pounds per acre of coffee with the parchment removed, whereas the two plats receiving complete fertilizer produced at an average rate of 475 pounds. The fertilizer applications were at the annual rate of 225 pounds of ammonium sulphate (or its equivalent in sodium nitrate), 300 pounds of acid phosphate, and 100 pounds of potassium sulphate. In 1925 the total cost of fertilizer at local prices, including transporting, mixing, and applying, amounted to about $18. At the prices received for coffee during the last several years this fertilization was carried on with a fair margin of profit. It is thought that higher proportions of potash than were used would have been advantageous. Therefore, certain plats heretofore receiving incomplete fertilizer will be given a complete mixture high in potash for comparison with the plats discussed above.

Coffee seedlings often develop badly twisted taproots. To determine the effect of position of seed in planting on resulting root growth, seeds in lots of 100 each were set in sand flat face up, down, and on edge, and radicle up and radicle down. Straight, strong taproots developed from all positions, showing that position of seed in planting had no effect on shape of the resulting taproot.

Coffea excelsa produced this year its maximum yield to date, an average of 3 pounds 2 ounces per tree, 10 years after seeding, or a little more than 8 years after being set in the plantation. These trees are spaced 12 feet apart, and though in poor red clay and unfertilized, they have grown so vigorously as to make closer spacing impracticable. One coffee planter whose plantation suffers heavily from leaf miner is planting this variety extensively on account of its resistance to leaf-miner attack.

COCONUTS

After four years of generous applications of fertilizer to the experimental plats of coconut palms at Corsica, the expected increase in production has not followed. The plats receiving complete fertilizer are, however, maintaining their yields, whereas the check has dropped in production.

For 10 years the station has been conducting a cooperative fertilizer experiment on the San Jose coconut plantation. The experiment was begun when the trees were very young. Individual yield records now cover six years. For treatment the trees were grouped in nine plats of parallel rows of 10 palms each. The record shows

very wide variations in yield between individuals of the same age receiving the same treatment and grown under very uniform conditions of elevation and soil. Some palms have given high yields year after year, whereas others equally favorably located have consistently produced very low yields.

Because of the pronounced variation and the very high probable error of the average plat yield, the previous treatments were discontinued and the whole planting devoted to the investigation of the effect of a single treatment, the application of sodium chloride, the new plats running at right angles to the old. Thus, groups were formed which previously received similar treatment and differ by less than 1 per cent in total yield for the past four years. The important point brought out by the individual record is that the inherited tendency toward light or heavy production in coconuts is a matter of paramount importance. Breeding productive strains offers promise of high returns.

BEANS

An extensive bean planting was made in April to compare local and imported varieties and strains that have been developed at the station. The black Venezuelan variety continued to show superior yielding quality, giving an average yield of more than 10 pounds of dried beans per 100-foot row. Guadeloupe Red and Porto Rico Red were the earliest of the local varieties, giving an average yield of about 1 ounce of snap beans per plant six weeks after planting. The earliest of the northern varieties, but a little less advanced six weeks after planting than the preceding, were Currie's Rust-proof Black Wax, Mohawk, and Extra Early Valentine. The northern varieties leading in yield of snap beans seven weeks after planting were Early Red Valentine, Mohawk, and Extra Early Valentine.

The flat, fibrous, and stringy Caribbean varieties are grown for snap beans for the local market and should be supplanted by northern varieties, such as Valentine bush or Kentucky Wonder pole, which yield well and are of superior quality. The local varieties should be planted for the production of shelled beans, for which they are better adapted than the northern kinds.

REPORT OF THE PLANT BREEDER

By R. L. Davis

FIELD CORN

Records are now available on 27 lines of corn which have been twice self-pollinated. These lines have for the most part originated from the highest-yielding parent ears obtained from the Peñuelas, Lajas, and Jayuya districts in 1924 and 1925. Considered in groups, the Peñuelas lines are far superior to the other lines, as was also the progeny of the first selfed generation.

The chances of developing a selfed line of corn which shall prove to be superior to normal corn in prolificacy is very slight with the Jayuya lines so far tested. They produced only 116.3 ears per 100 bearing plants and had less than half the number of two-eared plants in adjoining rows of normal open-pollinated corn. The chances are good, however, for isolating superior prolific lines from

Peñuelas and Lajas corn, for several partly purified lines, selfed only two generations, from each district, produced double the number of two-eared plants found in normal corn.

Approximately 1,000 plants have been bagged for self-pollination. The self-pollination work was largely concentrated on Castillear–1, which has been superior for two seasons in yield and in performance of selfed lines. Open-pollinated seed of this parent ear outyielded ordinary corn by 19 per cent in four replicated plats of 60 plants each. The outstanding feature of the corn work for 1926 has been the splendid performance of Castillear–1–5–1 and Castillear–1–5–2, two sister selfed lines from Castillear–1. The aim of this part of the selfing work is to isolate from Castillear–1 other equally vigorous lines which shall not be so closely related as are these two, and then to reproduce the superior yield of Castillear–1 by intercrossing.

In average growth and yields, 100 plants of each of the above-mentioned two superior lines were at maturity approximately the same as adjoining check rows of open-pollinated corn. Both are superior in yield to all other selfed lines. Their leaves are broader and greener, and their percentage of diseased plants is less than in the average selfed line. The two lines are practically identical in prolificacy, one yielding 141 and the other 142 ears per 100 bearing plants.

The prolific tendency in selfed lines as well as vigor of growth and yield seem to be strongly correlated in Porto Rican corn. Seven of the eight of the most prolific selfed lines were also the largest and highest-yielding lines.

Eleven selfed lines of Castillear–1 were superior in yield in the second self-generation to all other groups tested, although the superiority was not so marked as in the first generation. In the second generation the Castillear–1 lines averaged 54.5 per cent of the yield of the open-pollinated corn, as opposed to 45.4 per cent for seven lines from Cacique–1 and 43.5 per cent for seven lines from Vincens-Flint–2. If the best yielding selfed line from each group be compared with bulk open-pollinated corn, the percentage of reduction in yield appears to be quite different. If they are compared, however, with the yields of the original parent lines, the difference is not nearly so marked. Castillear–1–5–2, which yielded 3.1 per cent more than bulk open-pollinated corn, though apparently not reduced in yield, actually yielded only 71 per cent as much as the parent ear, and hence the true reduction in yield is 29 per cent. Cacique–1–2–1 yielded 71.6 per cent as much as bulk corn, but this is only 56.6 per cent of the yield for the parent ear and represents a real reduction of 44.5 per cent. Vincens–Flint–2–9–1 yielded 59.9 per cent of the check, but a comparison with the parent ear shows that the apparent reduction of 40.1 per cent is in reality 58.2 per cent. Thus, the apparent reductions in yield are −3.1, 28.4, and 40.1 per cent, respectively, whereas the actual reductions are 29, 44.5, and 58.2 per cent, respectively.

Imported varieties tested include Jala, Salisbury White, and Boone County White. Jala, the giant Mexican variety, grew 8 feet high and matured in four months, but was only 1 foot taller and two weeks later than the native corn. Jala was badly attacked by mosaic. This, however, does not explain its very small growth and early

maturity since mosaic-free Jala plants did not grow much taller than the native corn. Salisbury White corn from South Africa was inferior in growth and shows no promise under Mayaguez conditions. Boone County White, reported to have done well in the Philippines, has thus far made the most vigorous growth of any of the imported varieties tested at Mayaguez. It is attacked by worms, however, the ears being more severely damaged than are those of native corn growing in the same hills.

A second season's test of native corn from Barranquitas, Coamo, Morovis, Aibonito, and Lares again gives the Barranquitas corn first place in point of vigorous growth, and this notwithstanding the fact that Barranquitas corn grows at elevations approximating 2,500 feet, whereas Morovis and Coamo are situated in low altitudes, similar to Mayaguez. Vigor of growth was determined by the hill-check method. The check corn was bulk native seed which came from two farms near Yauco. The value of general observations on corn from each district is demonstrated in the case of the Barranquitas corn. The average more vigorous growth of this corn one month after planting indicated that the most vigorous ear-to-row selection would be found among corn from Barranquitas. This was found to be the case, parent ear Barranquitas–22 outranking in size 61 ears from five different districts three weeks after planting as well as at maturity. The longisectional area of all the ears of Barranquitas–22 was found to be 50 per cent greater than for the check corn. Barranquitas–22 was not only very prolific, but it also produced longer ears than the average. High-yielding parent ears were also found in corn collected from Coamo, Aibonito, Lares, and Morovis. The estimated yields were based on the longisectional areas because the crop was damaged by hurricane prior to maturity.

Six hybrids between corn lines that had been selfed through one or two generations were tested by interplanting them with bulk native corn. Four of the six were superior in yield to the check, the superiority in each instance being due to increased prolificacy rather than to size of ears.

MUSKMELONS

Of eight selected seventh generation hybrids of the native muskmelon crossed with Salmon Tint Pollock which were tested for vigor of growth, Nos. 3, 5, 6, and 7 gave the most promise. The work was therefore concentrated on these selections. A second planting was made in a plat on which melons previously had been destroyed by downy mildew. The hills of each selection were interplanted with the varieties Honey Dew and Casaba. Mildew destroyed all the vines of Casaba, Honey Dew, and hybrids Nos. 3 and 5. One vine of hybrid No. 7 resisted mildew, and 9 of 10 vines of hybrid No. 6 resisted mildew and matured fruit. Hybrid No. 6 is segregating into long large and small round fruits and is being further tested to isolate, if possible, a medium-to-large fruit having the flavor of the Salmon Tint Pollock.

TOMATOES

In continuing the work to improve the tomatoes of the island. Norton No. 61 was planted in every other row at the station to serve as a check. Four of the more promising hybrid selections and the

variety Richard Diener were included in the test. The Richard Diener was inferior to the check variety in vigor of growth, and the leaves of many of the plants died before the fruit matured, whereas the leaves of adjoining check plants remained green and healthy to the end. The hybrid selection of New Century crossed with Insular Station–245–3–1 lacked vigor and was discarded. Tomato yields were not calculated with the hybrid selections because of the amount of segregating present. Reselections were made from New Century × Insular Station No. 113–7–2, New Century × Insular Station No. 113–7–1, and Insular Station × Richard Diener No. 1–10–21. Of these three lines, the first mentioned seems to be the most vigorous and prolific.

SUGAR CANE

CULTURAL EXPERIMENTS

Cultural experiments were continued to determine the best methods for propagating cane seedlings. One of the reasons for the marked variation in the germination per arrow is the variation in the size of the arrows. Counts of composite one-tenth gram samples showed that Uba cane averaged 12,590 "seed"[8] per arrow, whereas P. O. J. 2725, S. C. 12/4, and H. 109 ranged from 27,000 to 34,000. The number of "seeds" per gram is fairly constant, and the weight of fuzz rather than the number of arrows should be used in measuring the rate of application in germination flats. About 25 grams of fuzz per square foot gives a wet layer approximating a quarter of an inch in depth, which is satisfactory for Mayaguez conditions.

Fertilizer (acid phosphate 2 parts, and ammonium sulphate and potassium sulphate 1 part each) applied at the rate of 2 grams per square foot of germination flat, gave increases of 16 to 29 per cent in the stands secured. The fertilized area not only showed increase in germination but also in plant growth; this was a third again as large as the growth on untreated flats.

Sealing in air-tight containers with quicklime was found to prevent loss of viability of seed. The lime was separated from the fuzz by a layer of paper and was placed loosely in the bottom of the container. Fuzz which had been stored with lime 20 days gave a 28 per cent higher stand four weeks after seeding than did fuzz that had not been so stored.

The effect of greenhouse conditions on cane seedlings was found to be very favorable during the first four months of growth. (Fig. 10.) Forty days after planting seedlings that were grown in the greenhouse were twice the size of those growing in the open under the direct rays of the sun. The latter lot, however, suckered more freely than did the former.

In a comparative test made to determine the superiority of transplanting seedlings to flats or pots over letting the plants remain in germination flats until time for transplanting to the field nursery, seedlings that were allowed to remain undisturbed made much better growth than did those which were transplanted. (Fig. 11.)

Results of experiments with different proportions of "cachaza" or filter-press cake indicate its undesirability as compared with well-

[8] The term "seed" here means the number of individual flowers per arrow whether fertilized or not.

rotted manure for use in the propagation of young cane seedlings. The "cachaza" stunted growth in both the germination flats and the flats used for transplanting.

BREEDING

Approximately 150,000 seedlings were germinated in 1926. Elimination was rigorously practiced in the germination flats, and frequently not over 3 per cent of the seedlings were retained for the field nursery. Most of the seedlings were left in the flats until of an age for transplanting to the field. Seedlings reaching the field included S. C. 12/4 (2,500), the progeny of Crystallina × S. C. 12/4 (3,000), and the progeny of P. O. J. 2725 × S. C. 12/4 (500).

FIG. 10.—Seedlings (Crystallina × S. C. 12/4) 70 days old. Right, grown in the hothouse under glass; left, grown in the open

REPORT OF THE AGRICULTURIST

By H. C. HENDRICKSEN

PINEAPPLE INVESTIGATIONS

Pineapple growers in Porto Rico are confronted with many problems needing solution. Some of the plants may bloom a few weeks after setting but produce fruit of no value; other plants may not bloom for two years after setting and then produce small, deformed fruit. Again, plants may, under apparently favorable conditions, produce fruit that is above or below the average. Results of experiments have shown that certain fertilizer ingredients in the soil may produce such great differences in the crop as to cause even experienced growers to pronounce the fruits of different variety. In cer-

tain fields where there is a strong tendency to produce large fruits on thin, brittle stems, very great loss is experienced as the result of broken stems. Often isolated areas in some particular field, and sometimes the whole field, may fail to produce profitable crops. Some of these problems have been solved, at least in part, by means of the soil investigations reported upon last year, and fields in which crops previously failed now bear profitable crops. Planters who availed themselves of the information resulting from the investigations are not planting in soils that have been found to be unsuitable for pineapples. The investigations are being continued.

The work of the year was confined almost exclusively to inorganic and biochemical analyses of abnormal plants and normal plants from adjacent areas, and plants in which abnormality was produced by

FIG. 11.—S. C. 12/4 seedlings 66 days old. Right, thinned and left in the germination flats; left, transplanted

artificial means. The investigations are helping to answer many questions of practical importance, but have not advanced sufficiently to permit publication of results at this time.

FRUIT GROWERS' MEETINGS

The agriculturist held four field meetings during the year for citrus and pineapple growers of the fruit section between Rio Piedras and Arecibo. Get-together luncheons were given monthly in San Juan and attended by 30 to 50 planters. These meetings enable the agriculturist to keep in close touch with the fruit growers with little loss of time and effort. Records of the meetings were published in mimeographed form for distribution among growers whom it would be difficult to reach in any other way.

REPORT OF THE PLANT PATHOLOGIST

By C. M. TUCKER

COCONUT BUD ROT

In November, 1925, a campaign was undertaken for the eradication of coconut bud rot, which has become epiphytotic in the groves along the western coast of the island. *Phytophthora palmivora* is the causal organism of the disease. The eradication work has been under the direct supervision of agricultural agents from the insular department of agriculture and has been carried on at Mayaguez, Cabo Rojo, Yauco, Aguada, Aguadilla, and Isabela. Diseased groves have been located, bud-rot cases diagnosed, and infested palms destroyed by felling and burning the leafy crown and bud. The preliminary survey revealed 127 infected groves representing 2,608 acres of land with 399 active cases of bud rot; that is, cases in which the disease is considered to be in the right stage for dissemination. Of older cases in which all the leaves had fallen, 1,138 were reported. The distribution of infection in the various districts is shown in Table 1:

TABLE 1.—*Results of 1925 survey for the eradication of coconut bud rot*

Section	Infected groves	Total area of groves	Palms to be destroyed	Dead palms	Total loss in palms
	Number	*Acres*	*Number*	*Number*	*Number*
Aguada	29	789	113	86	199
Aguadilla	5	51	20	88	108
Anasco	20	317	61	338	399
Cabo Rojo	31	695	81	238	319
Mayaguez	42	756	124	388	512
	127	2,608	399	1,138	1,537

The 399 active cases recorded in Table 1 were destroyed during the early months of 1926.

Reinspections of infected groves and adjacent properties are made necessary by reason of the long incubation period of the disease (3 to 12 months or more) and are of value in permitting destruction of the disease in its early stages. Infected palms become centers of infection with the death of the youngest emerging leaf, which is the first symptom of bud rot. The first reinspection was therefore made in April, 1926, and the results are shown in Table 2.

TABLE 2.—*Results of second inspection for the eradication of coconut bud rot*

Section	New properties infected [1]	Total area of infected property	New cases of bud rot
	Number	*Acres*	*Number*
Aguada	8	300	37
Aguadilla	5	71	21
Anasco	1	8	8
Cabo Rojo	0	0	1
Isabela [2]	1	30	5
Mayaguez	3	10	21
Yauco [2]	1	1	1
	19	420	94

[1] All infected trees found on reinspection were destroyed.
[2] Appearance of the disease in the Isabela and Yauco sections was noted for the first time.

The winters on the western coast are often very dry. The past winter was unusually dry, especially in the Cabo Rojo region, and the drought was not broken until May. This fact probably accounts for the appearance of only one new case in the Cabo Rojo region.

The infected groves and adjacent properties were inspected for the third time during the summer of 1926. The results of the survey are shown in Table 3.

TABLE 3.—*Results of third inspection for the eradication of coconut bud rot*

Section	New properties infected	Total area of infected property	New cases of bud rot
	Number	*Acres*	*Number*
Aguada	6	143	19
Anasco	0	0	2
Cabo Rojo	0	0	13
Isabela	3	85	10
Mayaguez	6	2	6
	15	230	50

The increase in the number of new cases appearing in the Cabo Rojo section began with the opening of the season of frequent rains. Of the 50 new cases discovered, 42 were destroyed. The work of eradication has not been completed, nor have the results of the third survey at Yauco and Aguadilla been received.

A NEW HOST OF PHYTOPHTHORA PALMIVORA

Early in 1926 a bud rot of the hat palm (*Sabal causiarum*) was reported from Joyuda, where the palm is grown in a limited area. The hat palms are grown in the coconut groves, and bud rot appeared in the two palms in close proximity. The disease symptoms were identical on both hosts, and, pending further investigations, the eradication measures employed for coconut bud rot were extended to include the Sabal bud rot. Isolations from infected petioles of dying Sabals gave cultures of a strain of *Phytophthora palmivora* which was identical morphologically and physiologically with the strain obtained from coconut bud rot. Inoculations of unwounded coconut palms were made by pouring a water suspension of the spores and mycelium of the Sabal strain among the emerging leaves of 10 mature palms. After 108 days three cases of typical bud rot had developed, and the remaining seven palms showed spotting of the pinnæ due to *P. palmivora* infection.

The initial survey of the hat palms at Joyuda, which is included in the Cabo Rojo section, revealed 19 infected groves containing 214 acres with 23 active cases of bud rot and 189 recently killed palms. The active cases were burned. A reinspection of the same locality in August showed 33 new cases. Apparently the Sabal is more susceptible to *P. palmivora* than is coconut. Whether this is due to an inherent character of the Sabal or to the sheltered position of the shorter Sabals among the coconuts has not been determined

SCAB-RESISTANT GRAPEFRUIT

First-generation hybrids resulting from crosses of the Duncan with the Triumph varieties of grapefruit came of bearing age during the year. The crosses were made in the hope of isolating a commercially valuable scab-resistant strain or variety of grapefruit. The fruit borne by the hybrids was in every instance heavily scab infected, and confirmed the observation of Winston, Bowman, and Bach[9] on susceptibility of Rutaceous plants to scab, that "with but few exceptions, citrus hybrids are at least as severely attacked as the most susceptible parent." The second-generation hybrids will be watched for apparent recessive character for resistance.

MISCELLANEOUS NOTES

In an investigation, begun three years ago on vanilla root disease, a Fusarium of the Elegans group, which is closely related morphologically to *F. batatatis*, has been established as the causal organism in Porto Rico.

The pigeon pea is attacked by anthracnose, resulting in spotting of the pods and leaves and destruction of the seeds. Infection is most serious during periods of heavy rainfall. The causal organism is referred to *Colletotrichum cajani* and is now first recorded as the cause of a pod and seed disease.

A large part of the year was devoted to investigations facilitating the work of identifying Phytophthoras attacking tropical plants. Morphological studies were made as well as a study of the reactions of the strains on culture media and their pathogenicity to various hosts. A large number of cross-inoculations have been made, but the results are as yet too incomplete to permit of publication.

REPORT OF THE PARASITOLOGIST

By G. DIKMANS

Much of the work of the year was devoted to studies of hookworm development in the latrine and the pollution of the surrounding area, and to determining the value of paradichlorobenzene as an anthelmintic.

In continuation of investigations begun to determine what animal parasites affect domestic animals in Porto Rico, many fowls, including chickens, guinea hens, and some turkeys and ducks, were examined. The chickens and guinea hens showed a high rate of infestation with roundworms. The chickens in addition sometimes harbored numerous tapeworms or small numbers of flukes. Examination of a duck revealed the presence of two flukes of the genus Prosthogonimus. This parasite was recently reported by Chandler and Kotlan as causing a serious disease of chickens in Michigan.

One of the chief enemies of the poultry industry in Porto Rico is the mongoose, which was originally introduced to combat the rat. Several of these animals when killed and examined revealed nothing

[9] WINSTON, J. R., BOWMAN, J. J., and BACH, W. J. RELATIVE SUSCEPTIBILITY OF SOME RUTACEOUS PLANTS TO ATTACK BY THE CITRUS-SCAB FUNGUS. Jour. Agr. Research 30: 1087–1093. 1925.

of a parasitic nature. Five Acanthocephala were found in one mongoose, but owing to their distribution—one in the stomach, two in the small intestine, and two in the large intestine—it was thought that the worms were parasites of some animals that had been eaten by the mongoose rather than of the mongoose itself. The same stomach contained the undigested remnants of either a frog or a lizard.

During the dry season two complaints were received from San Juan and Mayaguez, respectively, of infestation of baby chicks with the sticktight flea (*Echidnophaga gallinacea.*) In both instances the chicken yards were located on sandy ground near the seashore. The insect probably is widely distributed over the island. Hatchings generally are avoided during the rainy season because of the presence then of "moquillo" (roup), and if the sticktight flea must be combated during the dry season a study of its prevalence and distribution will be well worth while.

A herd of cattle in Lajas was found to be rather heavily infested with lice. This was surprising, since the presence of lice usually is associated with crowded conditions such as prevail in the States during winter stabling. The infested animals are practically never indoors. They are turned to pasture after the morning milking and allowed to remain until about 3 o'clock, when they are driven to a large corral adjacent to an open shed with concrete floor. The animals are milked in the shed and left in the corral overnight. The lice were found in numbers in the switch of the tail, but on no other part of the body. A goat belonging to the agricultural college showed a heavy infestation with lice over the whole body. This animal also harbored several ticks.

Examination of skin scrapings from a horse at Guayanilla showed the presence of the mite *Psoroptes communis.*

The general health of the station animals was excellent. The usual number of foot troubles and digestive disturbances occurred, but nothing of a very serious nature. Fecal examination, by the Willis flotation method, of all the animals in the dairy herd, as well as of several animals from the college herd, showed only slight infestation with animal parasites.

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PORTO RICO AGRICULTURAL EXPERIMENT STATION
MAYAGUEZ, P. R.
Under the supervision of the
UNITED STATES DEPARTMENT OF AGRICULTURE

REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION

1927

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PORTO RICO AGRICULTURAL EXPERIMENT STATION, MAYAGUEZ

[Under the supervision of the Office of Experiment Stations, United States Department of Agriculture]

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REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION, 1927

CONTENTS

REPORT OF THE DIRECTOR

By D. W. May

During the fiscal year covered by this report the weather was generally favorable to crop production. The rainfall was abundant, and there were no severe storms. However, the effect of the hurricane which swept over the island in July, 1926, was apparent in the greatly lessened yield of coffee.

Studies were continued with the pineapple, with especial reference to its composition, habits of growth, fertilizer requirements, and the correlation of plant and soil, to learn, among other things, what compounds tending to inhibit growth are formed by the plant in the soil when rotation is not practiced.

The coffee groves of the island have for some years shown a decreasing production. Yields per tree may be increased by the use of fertilizers. Experiments are being continued to learn what fertilizer combination can be made to give the most profitable yield of coffee.

Studies of nitrogen utilization by cane soils which have been conducted during the last five years were brought to a close. These sought to show the value of leguminous crops in producing nitrogen in lieu of the purchase of this most expensive element in fertilizers.

The substitution of improved methods of propagating carefully selected, vigorous seedlings of known parentage and high-sucrose content for the old method of sowing seed from arrows that have been

selected at random will doubtless contribute toward the progress of the local sugar industry.

Some of the work of the station in plant pathology was done by A. S. Muller, of the College of Agriculture of the University of Porto Rico, in the absence of the regular station plant pathologist, who devoted most of the year to postgraduate work at the University of Missouri. The plant troubles of greatest concern at present include coconut bud rot, citrus scab, and a disease of citrus which apparently attacks the roots of the trees and ultimately causes their death.

The reports of the parasitologists show that a large number of parasites affect the livestock of the island. Notwithstanding an equable climate and an abundance of nutritious grasses during a 12-month growing season every year, there can be no full development of the livestock industry in Porto Rico until the hordes of internal and external parasites which prey upon the animals are brought under control or are exterminated.

REFORESTING

Forest trees make rather slow growth. Every planter of trees is therefore helping in the great work of hastening reforestation. Usually deforested areas have been baked by the sun or leached by the rain, or both, and in consequence are poor in natural fertility. Such areas in Porto Rico are mostly on hillsides that are not adapted to cultivation by machinery. For the smaller areas, fruit-bearing trees, such as the avocado and the orange, may be grown to advantage. Such plantings will enable the grower not only to add materially to his family food supply but also to market the surplus products. For the larger areas mahogany is more promising. Its marketability as a native wood of economic value is certain. Results of experiments at the station during 20 years show that the mahogany will thrive in a great variety of situations. Leguminous nurse crops, preferably trees, should have first consideration in the work of reforesting tropical lands, and can be grown before the main crop is planted, or the two crops may be interplanted to their mutual advantage. Where the trees have been removed from the land the soil usually is deficient in nitrogen, and it is impracticable to purchase nitrogen fertilizers in a scheme of planting for long-deferred returns.

The adaptability of many leguminous trees to certain regions as nurse crops for forest plantings has been demonstrated. The trees include *Acacia* sp.; *Prosopis juliflora*, the pods of which furnish a large amount of palatable feed for stock; *Cassia* sp.; *Gliricidia sepium*: and *Erythrina* sp. Both *G. sepium* and *Erythrina* sp. can be propagated from cuttings and from seed. Some of the leguminous trees can be cut for use as charcoal when their service as nurse crop is no longer needed.

Oil-Bearing Trees

Aleurites moluccana, which was early introduced into Porto Rico, *A. fordii*, or wood-oil trees of China, and *A. trisperma* do well on cut-over areas. *A. trisperma* was introduced by the station from the Philippines and apparently is the most productive of the three species. All three produce hard-drying oils which are suitable for lacquer making, and should be grown on a commercial scale in Porto Rico.

Table 1 gives the constants of the oil of the three species, obtained by different methods of separation.

TABLE 1.—*Comparative constants of the oil of three species of Aleurites*

Determination	Oil of *A. fordii*[1]	Oil of *A. moluccana*[2]	Oil of *A. trisperma* (seed)[3]	Oil of *A. trisperma* (whole seed)[3]
Average index of refraction	1.5092	1.4762	1.4929	1.4927
Specific gravity	.9410	.9270	.9380	.9383
Acid number	4.0000	2.3000	4.4000	7.1000
Saponification number	192.0000	192.3000	194.0000	190.0000
Iodine number[4]	(4)		(4)	(4)
Iodine number[5]	167.8000	162.0000	164.2000	160.5000
Tung oil heat test[6]	(6)	(7)	(7)	(7)

[1] Tung oil or Chinese-wood oil.
[2] Lumbang oil or candlenut oil.
[3] Soft lumbang oil. "Seed" refers to the kernel alone; "whole seed" refers to the shell and the kernel.
[4] Hanus method. Unsatisfactory.
[5] Hubl method.
[6] Browne method. Firm, crumbly jelly in 10 minutes.
[7] Browne method. Negative.

A manufacturer of tung oil, in a letter to the station, comments as follows on the oil from *A. trisperma*:

Two samples of the oil were received. One was crushed from the seed and one from the whole seed; the former, of course, being lighter in color. Both, however, were of a light amber color, somewhat paler than the commercial grades of lumbang or tung oil obtainable in the market. The odor of each was similar, strongly resembling that of tung oil. In body they also resembled tung oil, being rather viscous.

When the "soft lumbang" oil was spread on glass it dried in 34 hours to an opaque, crystalline film, resembling the film that is produced by raw tung oil. When 10 per cent of lead-manganese drier was added to the "soft lumbang" oil a perfectly clear, firm film was obtained on glass in 14 hours. This result indicated that the oil could be used without heat treatment in the same manner as linseed oil in the manufacture of paints. This result differentiates the oil from tung oil, which is very difficult to use without heat treatment if perfectly clear and hard films are desired.

A small amount of the oil was exposed to the air and sunlight in a partially filled test tube for a period of one week. At the end of that time, an opaque, crinkled mass, light in color, was shown. This mass was removed from the tube. Upon pressure it readily granulated to a meal resembling the meal formed by crushing heat polymerized tung oil. This peculiar physical condition would suggest its use as a filler for inlaid linoleum.

It was found that the granular mass referred to above is of a different nature than the mass formed by heat polymerization of tung oil. Granulated polymerized tung oil is practically insoluble in all solvents and even little affected by boiling caustic soda. The mealy mass from the "soft lumbang" oil was found to be readily soluble in caustic soda (10 per cent solution) with the formation of a clear soap. It was also found somewhat soluble in boiling alcohol.

"Soft lumbang" oil, like true lumbang oil, is not affected by heat as is tung oil, and does not polymerize when brought to 280° C. and held at that temperature for a period of even 15 minutes. During this process, however, the oil becomes viscous (bodied) and apparently is well suited to use in the manufacture of varnishes. Experiments were made in the production of a varnish with "soft lumbang" oil on the same formula used in the manufacture of a tung oil varnish. For this purpose there was used with both oils a percentage of linseed oil and rosin with lead as the drier and mineral spirits as the thinner. Both oils were treated in the same fashion. The tung oil varnish had better body and slightly more rapid drying properties than the "soft lumbang" varnish. Both gave very waterproof films.

Stimulation of the production of "soft lumbang" oil in both the Philippines and Porto Rico should result in available quantities of this oil for use in the United States. Its properties make it most desirable for use in the paint and varnish industry.

FARM-BUILDINGS MATERIALS

Although the solid structures of the North are not required to house livestock in Porto Rico, where the climate is tropical, some kind of building is necessary. Milking sheds are required where dairying is practiced, and stables must be provided to house young stock during their early life and in rainy weather. Farm buildings are uncommon in Porto Rico, the native timbers are scarce, and building material is expensive. The lumber which is now used locally is imported from the States at high cost, and bricks, which were made on the island in the earlier days, are no longer used because of the high cost of the fuel needed in burning.

In seeking for an available material that will prove to be suitable for building purposes, the station carried out a series of experiments with soft limestone, or coral deposit, locally known as "tosca." (Fig. 1.) This material is found in extensive east-and-west deposits

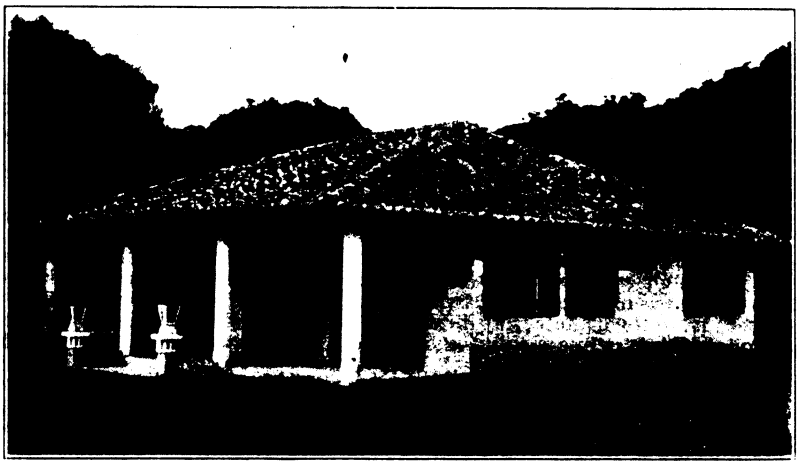

FIG. 1.—House built of soft limestone, or coral deposit, locally known as "tosca"

on both the north and south slopes of the island. These deposits at one time formed the bed of the sea, and on the north side jut out in jagged hills. Exposure to air causes the surface of tosca to harden, but after the crust is broken the material can readily be cut with a spade. Tosca is used as a road-surfacing material, as a ballast for railroad tracks, and as a fertilizer where lime is needed. Table 2 gives the composition of two samples of tosca, one from Aguadilla, on the west coast, and the other from Quebradillas, on the north side.

TABLE 2.—*Composition of two samples of tosca*

	From Aguadilla	From Quebradillas
	Per cent	*Per cent*
Sand and silica (SiO_2)	1.47	5.19
Lime (CaO)	53.76	50.65
Magnesium (MgO)	.87	.77
Ferric oxide (Fe_2O_3)	.56	1.09
Loss on ignition	43.39	41.72

Tosca when mixed in various proportions with cement was found to set quickly and to harden. A mixture as lean as 20 parts tosca to 1 part cement will harden sufficiently for wall building. The proportion of 10 to 1 was found by test to possess two-thirds the hardness of concrete. Tosca is vitreous, does not crack when drying, and therefore does not need to be reinforced with iron. The surface of the combination for use as floors may be further hardened with water glass, or such other chemicals as are used to harden concrete. Tosca mixes easily with cement and can be poured as readily as concrete. The availability and cheapness of tosca should lead to its extended use. It is delivered by railway to the station at $1.50 per cubic meter.

Adobe, or sun-dried bricks with straw as binder, may be used as a building material in the drier parts of the island, and pisé de terre, or rammed earth, for wall building where the rainfall is more abundant. Rammed-earth construction is durable, can be done by unskilled labor,

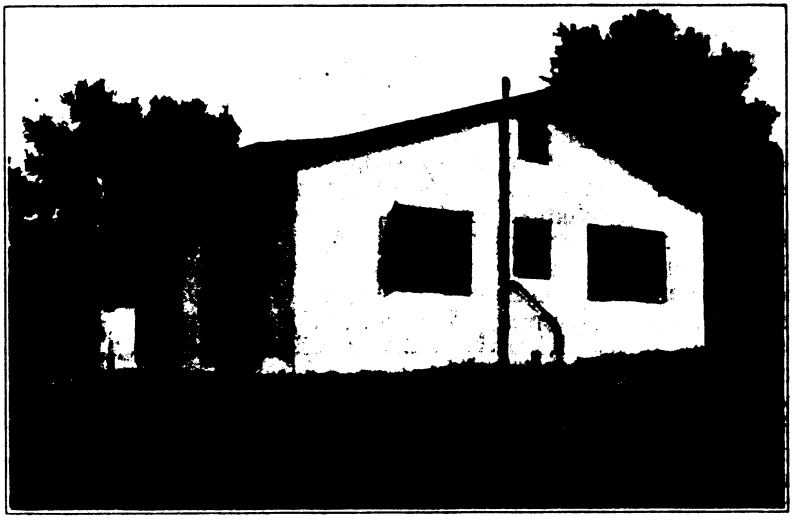

FIG. 2.—House built of pisé de terre or rammed earth

or by the builder in his spare moments, and enables the smallest landowner to erect his own home.

At the station, where the annual rainfall is about 75 inches, the house shown in Figure 2 was built on a concrete foundation and the walls were brushed with tar. The walls were rammed between 2-inch board casings which were well braced to keep them from spreading. The door and window frames were made of 2-inch material and placed when the building was of the proper height. The earth was then rammed at the sides and on top. With a little experience the builder can soon learn what amount of moisture is needed for the most efficient tamping. When the layer is done the earth gives off a ringing sound under the rammer.

FORAGE CROPS

Leguminous plants which produce an abundant supply of palatable and nutritious forage and at the same time increase the nitrogen content of the soil should be given first consideration when feed is to be

grown for livestock. Every grower should learn what legumes will grow successfully in any system of rotation he may practice and whether these same legumes will be relished by the stock on his farm. Legumes should not only be adapted to the soil and climatic conditions in which they are grown, but they should also be able to hold their own successfully, with the minimum cost of cultivation, with tropical rank-growing grasses competing with them. Clovers, for example, should not be grown in regions of heavy rainfall. They are slow in starting and therefore are soon smothered out by grasses and weeds unless given frequent cultivation, which is an unprofitable practice.

The cowpea thrives in Porto Rico and should be more generally grown than it is at present. The vines make excellent stock feed, and the peas, large quantities of which are imported from the States, can be used for human consumption. Some of the vast areas of idle lands throughout the island might well be devoted to the crop.

The soy bean is destined to become one of the important forage and food crops of Porto Rico. Soy beans improve the soil and furnish a larger variety of food products than does almost any other single vegetable. For the successful growing of this crop suitable nitrogen-fixing bacteria are necessary. If they are not already present in the soil, inoculation must be resorted to. Results of experiments at the station show that the soy bean makes its best growth when the seed is inoculated before being planted. The plant grows more rapidly than does the cowpea, matures earlier, and is less likely to be attacked by insect pests.

The velvet bean has been found by the station to be a most valuable forage and green-manure crop for general planting. The plant adapts itself to a wide range of soils in Porto Rico and is of easy cultivation. After the plant starts it will hold its own, climbing over grasses and weeds. Providing the vines with supports promotes seed production. Corn and sunflowers can be used for this purpose. Velvet beans should be planted at the last cultivation of the corn and sunflowers and may also be profitably planted in the stubble remaining after each crop of elephant grass and Guatemala grass is cut.

Uba cane is beginning to be grown for forage in Porto Rico. It ratoons well, tillers profusely, and is a very heavy yielder. A well-balanced green ration may be obtained by interplanting Uba cane with velvet beans at each cutting.

CATTLE

Any excellence characterizing the native cattle is due mainly to the mild, equable climate and the nutritious grasses of the island. The animals are better than might be expected where selection in breeding and concerted efforts to improve them for specific purposes have been neglected. The cattle have been largely employed as draft animals, either in plowing the land or in hauling cane to the mills, and although they have all but been driven from the highways by the autotruck, some are still used in the cane fields. Improvement of the native cattle can best be brought about by crossing them with introduced breeds. Crossbreeding should be directed principally toward improvement in size, vigor, and early maturity for the purpose of increasing strength in the male and quality and quantity of milk in the female.

Within recent years practically every breed of dairy cattle has been brought into Porto Rico. Given good grass and clean water, they have in the main done well. The short-haired breeds have been the least infested with ticks. Very fine progeny, showing improved conformation, early maturity, and increased milk production, have been developed by crossing Milking Shorthorns with the native cattle. Results of experiments in breeding at the station and elsewhere on the island show that of the imported cattle the Milking Shorthorn sire is the best for use where improvement in milk yield, strength, and conformation is sought. The breed is gentle, and even the males may be safely yoked and kept in inclosures having a minimum amount of fencing.

For dairy purposes, the Guernsey seems to be best adapted for improving the native cattle. Guernseys are similar in type to the native cattle, being stocky and strong, transmit their milking qualities to a high degree, and acclimate readily. In milk yields the crossbreds show steady improvement over the native cattle, the average yield of third-generation animals at the station having been increased by more than 70 per cent over their granddams.

That dairying should be developed to supply dairy products, especially milk, for local needs, is shown by the fact that in 1926 the island imported from the States 4,383,371 pounds of powdered and condensed milk, 4,387,896 pounds of cheese, and 593,883 pounds of butter.

THE BANANA

The banana as an important plant of economic value is not fully appreciated by the people of Porto Rico. Plantation owners have never considered the banana as a money crop, and individual laborers on the plantations have grown the fruit largely for the purpose of increasing their food supply. No attempt has been made to solve the market problems of the fruit or to learn how the plant can best be propagated to increase yields. The fruit is in demand on the local markets the year around and should be grown on a commercial scale for profitable shipping to the markets of the mainland.

The banana is of easy culture and is readily propagated from suckers. Shading the ground by the plants reduces cultivation to the minimum. The plant responds to fertilizer and is not easily injured by applications in excess of actual needs. Fertilizers may be applied about the plant, or in small amounts in the axils of the leaves whence they are carried by the rains down the stems to the roots. The banana grows rapidly and for a large plant matures quickly. To make its best development it must receive the proper kind and amount of plant food and be provided with good drainage. Analyses of the banana plant at the station showed that of the three fertilizing elements nitrogen, phosphorus, and potash, potash is found in unusually large percentages. The percentages varied in the different varieties. Gigante (Gros Michel) was found to contain 2.89 per cent potash in the dry matter; Manzano (Apple), 1.8 per cent; Señorita (Lady Finger), 3.7 per cent; Morado (Red), 4.02 per cent; Chamaluco (cooking), 1.83 per cent; and Enano (Cavendishii), 12.17 per cent.

There was a striking relation between the potash content in the above-mentioned varieties and their freedom from disease. Enano, for example, which contained the largest percentage of potash, was

immune to fungus diseases which attacked the other varieties in varying intensities, whereas Chamaluco, which contained the smallest percentage of potash, was readily attacked by disease and completely wiped out after a short time. Experiments at the station also showed that banana plants which received heavy applications of potash continued to grow from new suckers, whereas plants which were denied this element readily succumbed to disease. Successful culture of the banana would seem therefore to depend upon the growing of vigorous varieties showing a high degree of resistance to disease, the amount and kind of fertilizer given the plant, and good drainage.

REPORT OF THE ASSISTANT CHEMIST

By J. O. Carrero

MANAGEMENT OF CANE SOILS

Studies on nitrogen utilization by cane soils were brought to a close during the year. A résumé of the work follows:

Until recently no attention was paid to the necessity of returning to the soils the fertilizing elements extracted from it by crops. This fact was impressed upon cane growers and other planters in late years by contrasting the constantly decreasing yields, complete failures during abnormal years, and the necessity of having to replant after two or at most four ratoon crops, with the higher yields and the freedom from necessity of replanting until after harvesting 8 to 10 fine ratoon crops in the same fields in earlier years. It thus became a common practice to increase yields by applying commercial fertilizers, either singly or in combination, to the soil, but little consideration has been given to the possibility of obtaining some of the essential elements from less expensive sources, such as from a better use of the refuse and stubble remaining on the field after harvesting.

Growers of cane in Porto Rico ought to be especially interested in the problem of economic and efficient fertilization, for of the fertilizing elements added to the soil, only lime is prepared on the island. The others are brought in from the outside, thus making their use costly.

In cane fields burning of trash and tops is commonly practiced after the crop is cut, and in places where labor is high burning is done even before the crop is cut. Burning may be labor-saving, but it is wasteful of nitrogen and organic matter, two of the most important soil constituents. From 50 to 70 per cent of the nitrogen which is extracted from the soil by cane crops is found to be in the tops and the trash, and smaller amounts are found in the juice and bagasse. The nitrogen in the bagasse is lost when it is burnt, whereas part of the nitrogen of the juice can be recovered and returned to the soil on clarification of the juice. The largest share of the nitrogen taken up by the crop is lost when the tops and trash are burnt. Experiments at the station were, therefore, planned to learn whether part of this nitrogen could be recovered and in addition the organic matter content of the soil increased by returning the tops and the trash to the soil.

The experiments were made on thirty-six $\frac{1}{40.5}$-acre plats where the ground is level and the composition is fairly uniform. The plats were treated with phosphoric acid and potash at the rate of 60 pounds per acre. Half the area was limed and the other half unlimed. In the

first series, 12 plats, 6 limed and 6 unlimed, received no nitrogen. In 4 of these the trash and tops were burnt, and in 2 of the 4 green manure was used. In the other 8 plats the tops and trash were either plowed under or used as a mulch. In 4 of these 8 plats green manure was used every time cane was planted. In the second series of 6 limed and 6 unlimed plats, sodium nitrate was applied to 8 to furnish nitrogen at the rate of 60 pounds per acre, and to the other 4 at the rate of 30 pounds per acre. These 12 plats were treated like the no-nitrogen plats with respect to the trash, tops, and green manure. In the third series, 12 plats received nitrogen at the same rate as the sodium nitrate plats, but in the form of ammonium sulphate, and were treated like the no-nitrogen plats with respect to the trash, tops, and green manure.

Plowing under of tops, trash, and green manure afforded little change for the better for the plant cane crop in the no-nitrogen limed section, but proved to be beneficial in the unlimed section. The first ratoon crop gave a complete reversal of this result, the limed section showing decided gains over both the unlimed section and plats where trash was burnt. In sections where nitrogen was applied either as sodium nitrate or ammonium sulphate no change was observed favorable to plowing under of tops, trash, and green manure. The yields for the limed and unlimed plats were the same, and no noticeable difference was observed between the plats on which the trash was burnt and those on which plowing under or mulching was practiced. The treatment failed to make the yields of the half-nitrogen plats equal the yields of the full-nitrogen plats. However, a comparison of the first ratoon crops showed that the yields from the no-nitrogen limed plats on which the trash and the tops were plowed under or used as mulch nearly equaled the yield from the half-nitrogen plats receiving sodium nitrate or ammonium sulphate, whereas the yield from the unlimed no-nitrogen section was considerably lower. Thus the gain from the employment of trash, tops, and green manure was made by the no-nitrogen crop, especially the limed section.

Analyses of samples of the juice were next made for total solids, sucrose content, and purity to find the effect of the treatments on juice quality. Only 60 per cent of the cane weight as juice was extracted by the mill. Examination showed a tendency toward slightly lower total solids and a more pronounced lowering of the sucrose content for plats receiving ammonium sulphate dressing, though this was not so large where green manure had been used and where half-nitrogen applications had been made. The first ratoons did not do as well as the plant cane. The no-nitrogen plats had the highest total solids and sucrose contents, with the sodium nitrate plats ranking a close second. The juice of cane from these plats was apparently unaffected in quality by the various treatments given the plats.

Samples of juices from plant cane from plats on which the tops and the trash had been plowed under were found to have a higher nitrogen content than samples from plats where burning had been practiced. The juices were apparently unaffected by the presence or absence of lime. The same tendency was observed regarding the phosphoric acid and potash contents, the samples of juice from plats on which trash had been plowed under having the higher percentage. These results were shown by the no-nitrogen and nitrate plats, whereas smaller gains

with the highest mineral content were shown by the ammonia plats. Samples of juices from the first ratoon crop showed loss in mineral content when compared with samples from the plant cane. However, the losses shown by juices from the no-nitrogen plats were smaller than those shown by the nitrate and ammonia plats, so that first ratoon juices from no-nitrogen plats had the highest mineral content, those from ammonia plats ranking a close second, and nitrate plats last.

Trash and tops gave a reversal of the results shown by the juices, for the first ratoon crop had a higher mineral content than the plant-cane crop. Trash and tops from plats on which trash and tops had been either plowed under or used as a mulch had a higher mineral content than did that from plats on which burning had been practiced, but the effect was greater for the no-nitrogen than for the nitrogen-fertilized plats. At the same time, the nitrogen content of the trash and tops from the no-nitrogen mulched plats was higher than from plats where burning had been practiced, and the same was true for the nitrogen-fertilized plats, though these gains were smaller than those shown in the former case. As for nitrogen, the content in the leaves and trash from mulched plats is higher than that from plats where burning was practiced, whether the plats were nitrogen fertilized or not. However, the gains shown by no-nitrogen plats were higher than those shown by the nitrogen-fertilized plats. This extra gain in nitrogen content for the no-nitrogen plats together with their gain in tonnage made the nitrogen recovery of the first ratoon crop decidedly low.

Examination of samples of soil from the different plats at the beginning and again at the close of the experiment showed a slight change toward neutrality in the limed no-nitrogen section, but no change in the unlimed section. The sodium nitrate plats remained the same, whereas of the ammonium sulphate plats the limed section showed a slight gain toward acidity and the unlimed section no pronounced gains. All plats on which the trash and tops had been burned, whether limed or unlimed and with or without applications of nitrogen, showed losses in nitrogen and carbon content. Sections on which the trash had been burned and treated with green manure but given no nitrogen showed gains in carbon, whereas sections receiving also nitrogen showed losses in carbon and nitrogen. Sections on which the trash had been plowed under or used as a mulch showed decided gains in carbon. This was true especially of the no-nitrogen and nitrate plats. The gains shown by the ammonia plats were smaller. The plats with no-nitrogen or sodium nitrate dressings were more or less constant in nitrogen content, whereas those receiving ammonium sulphate showed a loss throughout. This loss was unexpected, for the constant nitrogen content of the no-nitrogen and the sodium-nitrate plats was to be expected, as a decrease or an increase of at least 0.01 per cent in nitrogen content of the soil would have to occur before it can be detected by ordinary analysis and before it can be called remarkable. Such a change means that a gain or a loss of 200 pounds of nitrogen per acre would have had to be made by the plats. The plats under discussion were given only two green manure dressings and some in addition received nothing, others a total of 120 pounds, the rest 60 pounds of nitrogen as sodium nitrate or as amonium sulphate in two dressings.

From additional side experiments it was learned that the green tops rapidly decompose in the soil and that decomposition is greatly hastened by addition of lime. The dried trash decomposed more slowly than the green tops, but again decomposition was hastened by the addition of lime. Decomposition of the dried trash is slow at first but goes forward so rapidly later as nearly to parallel the rate of the green tops. However, neither green tops nor dried trash showed the rate of decomposition made by the green manure (velvet beans) used in this experiment.

REPORT OF THE HORTICULTURIST

By T. B. McClelland

PHOTOPERIODISM

Studies of the photoperiodism of various economic plants were continued. The shorter light exposure was slightly in excess of 11 hours prior to December, at which time it was reduced by 1 hour. The longer exposure was slightly in excess of 13½ hours until December, when it was extended 1½ hours.

The varieties of onions tested, including White Bermuda, Prizetaker, Yellow Globe Danvers, and Giant White Tripoli, failed to develop bulbs under either of the shorter light exposures. Under both the 13½-hour and the 15-hour daily light exposures the White Bermuda onions quickly formed bulbs and passed into the resting stage. The Prizetaker variety under both the normal and the 13½-hour daily light exposures developed chiefly spring onions, but under the 15-hour exposure formed good bulbs. The Yellow Globe Danvers showed comparatively slight difference in its development under the 11-hour, the normal, and the 13½-hour daily light exposures, remaining in, or developing slightly beyond, the spring-onion stage, but formed good bulbs under a 15-hour exposure. The Giant White Tripoli formed some bulbs under both the normal and the 13½-hour daily light exposures, but showed a more uniformly normal bulb development under the 15-hour exposure. This evidence readily explains the lack of adaptability of certain varieties of onions of the Temperate Zone to tropical conditions.

Little difference in growth in the first nine months was noted for pineapples under the 11 and 13½ hour daily light exposures. Subsequent observations showed that the longer period was the more favorable for vegetative development, blossoming being delayed and much larger fruits forming than under either the normal or the short daily light exposures. The plants were left undisturbed after fruiting for the production of a second crop from suckers. Under the 15-hour daily light exposure many of the older leaves remained turgid and green and continued to function in contrast with leaves of similar age and position, which had either dried or were wilting on the plants receiving the normal and the 10-hour exposures. Blossoming was again much retarded by the longer daily light exposure.

The varieties of white potatoes tested included Red Bliss, Lookout Mountain, and Irish Cobbler. While on the whole the shorter daily light exposure favored tuber formation and the longer exposure favored top growth, the varieties differed considerably in the degree to which they reacted; Red Bliss proving to be the least and Lookout

Mountain the most sensitive. Under a 15-hour daily light exposure Lookout Mountain developed an extraordinary amount of top growth and practically no tubers, whereas under the 10-hour exposure the top growth was much less and tuber formation fair.

Several varieties of corn were grown under both a normal and a 15-hour daily light period, it being impracticable to handle this crop under a shortened light exposure. Porto Rican corn was planted January 26 in a garden plat which was illuminated by 40-watt clear glass electric light bulbs set 6½ feet apart in rows 5 feet apart. The lights were placed at a distance of 3 feet above the soil surface and raised from time to time as growth of the corn warranted. Two months after being planted the corn receiving artificial illumination was taller than the check, but not tasseling, whereas the check was beginning to tassel. The first tassels appeared on the artificially lighted corn 17 days later, when all the normal check plants had finished tasseling and nearly all were silking. Although the artificially lighted plants grew much taller than the check plants the latter were higher in percentage of large, well-filled ears and in total production. For this tropical strain of corn the lengthened daily light exposure favored vegetative development, whereas the shorter light exposures were more conducive to fruiting.

Young coffee plants when kept for seven months under the 10-hour and the 15-hour daily light exposures showed no pronounced difference in growth due to difference in light exposures. The plants produced small, virescent flowers under the shorter light exposure, but developed no normal flowers in either group within the seven months.

COFFEE

The fertilizer tests with coffee were satisfactorily continued, and a bulletin embodying the results of the work to 1925 was issued.[1] Changes were made in the basal formulas used on certain plats at the López plantation at Las Vegas. Results of experiments having demonstrated the superiority of complete fertilizer over nitrogen alone, the plats heretofore receiving the latter were given this year a complete fertilizer high in potash for comparison with plats receiving nitrogen, phosphoric acid, and potash in approximately equal amounts. At present prices of coffee and fertilizer, the latter mixture, which has been applied to the López plats for some years, is producing a handsome profit on the investment in fertilizer. Plats of young coffee for testing the most favorable nitrogen-potash ratio are making fair growth, and a few of the trees are already carrying their first crop.

Scions which were taken from an Arabian tree of notably high yield through a long period of years were grafted on Excelsa seedlings to test the effect of this vigorous stock in increasing the yield of Arabian coffee. To the same end Arabian seedlings were inarched on Excelsa seedlings. Each Arabian individual on its own root will be grown alongside the scion which is being topworked on the Excelsa root. The hurricane which visited Porto Rico in July, 1926, greatly reduced the coffee crop at the station and elsewhere on the island. The coffee trees in some of the plats were injured so severely as to necessitate termination of the work on them. Due presumably to adverse

[1] McCLELLAND, T. B. EXPERIMENTS WITH FERTILIZERS FOR COFFEE IN PORTO RICO. Porto Rico Agr. Expt. Sta. Bul. 31, 34 p., illus. 1926.

weather conditions, the hurricane in July being followed by a severe drought in the winter, the crop is practically a failure in some of the experimental plantings.

Gliricidia sepium has proved to be highly satisfactory in the station plantings as a shade for coffee, and cuttings are being distributed to local planters. The cuttings strike root readily, and growth from both cuttings and seed is rapid.

COCONUTS

The coconut fertilizer work was continued without change. Applications of common salt to coconut trees in the Harvey plantation were begun in May, 1926, but the experiment has not as yet progressed sufficiently to learn the effect on production. For the year ended December, 1926, the treated trees produced on the average 68.5 nuts, whereas the check (untreated) trees led with an average production of 72.9 nuts. At Corsica the plats maintained or improved their yields when potash was included in the fertilizer combination and dropped in production when potash was omitted. The two plats receiving complete fertilizer were higher in yield for the year 1926 than the check and the two plats from which potash was omitted.

MANGOES

The Cambodiana mango is a polyembryonic variety which transmits its characteristics to many of its seedlings. The several seedlings from a number of seeds of the 1919 crop were separated and classified from each seed individually as to size to learn whether initial vigor or size is an indication of hybrid origin. Fourteen of these trees fruited for the first time during the year. Of these, 4 had been ranked as firsts, 4 as seconds, and 6 as thirds in vigor. One which had been ranked as a second showed hybrid origin, and the other 13 conformed to type. The former differed from type in being of smaller size, in having a pinker, thicker, tougher skin, a different aroma and flavor, firmer flesh, and much more abundant fiber. Along with these differences there were points of similarity clearly indicating its derivation from Cambodiana. The larger seedling from the same seed has not yet fruited. The results of the present season show that the largest seedling from a polyembryonic mango may fail to give evidence of hybrid origin, whereas a seedling other than the largest may give such evidence.

AVOCADOS

Additional grafted Guatemalan avocado trees were planted at the station. There are now 24 grafted varieties, mostly Guatemalan, at the station. It is believed that some of these varieties will be of great importance in lengthening the season in which avocados are to be had, which is now limited to a period of approximately five months.

ONCOBA ECHINATA

Twenty-five plants of *Oncoba echinata*, S. P. I. 55465, were sent to the station for trial in May, 1923. They produced their first fruits in a little over three years after being planted and are now fruiting freely. The plants have grown rapidly and vigorously in ordinary heavy red clay soil and apparently are well adapted to local conditions.

TARO, DASHEEN, AND YAM

In plantings of the Penang taro, an increase in the size of cormels used as seed pieces failed to produce a corresponding increase in yield. Cormels weighing from less than 2 ounces to 6 or more ounces were planted in four groups according to weight. The first size gave the heaviest and the second size the lightest yield. On account of its superior table quality and pronounced difference in this respect from any of the taros grown in Porto Rico in the past, the Penang taro is a desirable variety for the home garden. The station is attempting to establish the variety locally as a garden crop. The importation and testing of a new food crop is a simple matter, but its establishment in the gardens of the people is much more difficult. As a means of disseminating the Penang taro in Porto Rico the station placed a man along the roadside to describe the new vegetable to small farmers who were returning to the country. Samples, together with small cormels for planting, were also offered.

The lower-yielding varieties of dasheen, with the exception of Ventura, S. P. I. 47003, have been eliminated from the station plantings. Ventura produces very large handsome tubers, but is a comparatively low yielder, averaging per hill, for the last crop, 3⅓ pounds of corms and tubers of a size suitable for table use in comparison with approximately 5 pounds from each of the other varieties.

The collection of imported yams at the station has been redueed to a few high-yielding varieties. Of the imported varieties, Sealtop ranked highest in the crop of the year, with an average per hill of 3 pounds 15 ounces, and Purple Ceylon lowest, with an average per hill of 2 pounds 11 ounces. The local varieties gave a much lower average production, Guinea, the standard local yam, ranking highest, with 1 pound 9 ounces per hill, and Mapuey Morado lowest, with 6 ounces per hill.

REPORT OF THE PLANT BREEDER

By R. L. Davis

FIELD CORN

No well-established variety of corn which has been introduced into Porto Rico has thus far equaled the native corn in yield. Boone County White, an Indiana corn which grows well in the Philippine Islands, is commercially valueless in Porto Rico; Cuban Yellow, a small flint corn which yields satisfactorily in Hawaii, has failed completely, and Hickory King, a corn from Missouri which is reported to have done well in South Africa, was not worthy of a second year's trial. Thus, corn which is bred in other parts of the world can be relied upon to do well in Hawaii, the Philippines, and in South Africa, but must be developed locally to be successful in Porto Rico.

Crosses were made between a common open-pollinated variety of native corn and 27 lines of corn originating from high-yielding Porto Rican parent ears. These lines had only been self-pollinated twice, but it was thought that the best lines for additional selfing could be determined by comparing the yields of the hybrids with the yields of a common pollinator. Most of the hybrids were expected to equal and a few slightly to exceed in yield the ordinary native corn, which was used as the pollen parent. The results were very encouraging.

The average yield of the 27 hybrids was approximately 20 per cent greater than that of the check variety or pollen parent. Taken as a whole, the ears of the hybrids had very sound grain, and were much freer from mold and from worm injury than the ears of the check. The hybrid plants were sturdy and lodged less frequently than did those of the check variety.

SWEET CORN

While practically all of the vegetables that grow in the Temperate Zone can be and are grown in Porto Rico, no variety of sweet corn has as yet been found to be adapted to island conditions. Northern sweet corn makes very weak growth and usually produces small ears which are so severely attacked by worms as to be scarcely worth harvesting. Green corn is used extensively by the natives but is gathered from the common field corn and is frequently tough and unpalatable.

The station has been fortunate in securing some native sweet-corn seed which has every appearance of desirable quality. It originated from seed which was supplied by the station to S. W. Marvin of Villalba in 1925 and is the result of four seasons' selection work from a sport which was found growing in native field corn. This strain of sweet corn is known as Mayaguez-1. The ears are about 6 inches long and are not severely attacked by worms. The kernels vary in color from light yellow to light pink and are deeply shrunken and elongated like those of the Country Gentleman variety of sweet corn. In early growth the plants are vigorous and similar to those of the native field corn, but at maturity they are somewhat smaller than the latter.

FIG. 3.—Mayaguez-1 sweet-corn seedlings 30 days after the seed was planted. It is 2 feet high and free from worm injury

Figure 3 shows typical seedlings of Mayaguez-1 which at 30 days after planting averaged 2 feet in height and were comparatively free from worm injury. Seedlings of Country Gentleman and other sweet-corn varieties from the North at a corresponding age are not so high and invariably are riddled by worms. Figure 4 shows a typical mature

plant of Mayaguez-1 which measured 73 inches to the base of the tassel and was without worm injury. Sweet corn from imported seed usually grows 4 feet or less in height. Black Mexican does not average more than 2½ or 3 feet tall at Mayaguez. Mayaguez-1 was developed largely from the big sweet-corn ear shown in the upper row left, in Figure 5. This is the third season of selection for kernel type and freedom from worm injury.

SUGAR-CANE BREEDING

The goal of the sugar-cane breeder's ambition should be to develop improved varieties which will supplant the old. In Porto Rico and a number of other cane-growing countries seedlings are commonly propagated from arrows which have been selected at random and no consistent attempt is made to select the paternal parent. The best sugar-producing varieties in the East and the West Indies are, however, all of hybrid origin and indicate the efficiency of controlling both male and female parentage.

FIG. 4.—A vigorous typical plant of Mayaguez-1 which measured 73 inches to base of tassel and was free from worm injury

During the period 1918–1924, inclusive, some 40,000 seedlings of unknown paternal parentage were propagated at the station and planted in the field. Of this number not one superior variety worthy of commercial testing was developed. In 1925 approximately 5,000 seedlings of S. C. 12/4 were propagated and planted in the field. Of these only one has, during the 1927 season, given a tonnage that justifies additional testing of the hybrid. An examination of the records of hybrids of known parentage, made through the cooperation of the Fajardo Central at Fajardo, Porto Rico, in 1925, showed that of a lot of 350 seedlings of P. O. J. 2725 pollinated by S. C. 12/4, 45 were saved for a second year's trial, and of these, 10 at present are worthy of preliminary commercial testing.

The results of the first season's efforts at hybridizing at Mayaguez considerably exceeded expectations. A vigorous, drought-resistant hybrid, the result of crossing P. O. J. 2725 and S. C. 12/4 is shown in Figure 6.

FIG. 5.—Mayaguez-1 was largely developed from the large ear in the upper row, extreme left. Notice its sound grain as compared with that of the lower row ears which were discarded

FIG. 6.—Vigorous, drought-resistant hybrid seedling of P. O. J. 2725×S. C. 12/4. Mayaguez-7 on the right has at 4 months made double the growth of B. H. 10/12 on the left. B. H. 10/12 is suffering from drought, whereas Mayaguez-7 is green and healthy

Mayaguez-7 on the right has at 4 months made double the growth of B. H. 10/12 on the left. The latter suffered somewhat from the drought, whereas Mayaguez-7 remained green and in good condition. P. O. J. 2725 was crossed with S. C. 12/4 in the hope of developing a variety which would prove to be commercially resistant to the mosaic disease and give a tonnage production equal to that of P. O. J. 2725, but lack its early arrowing habit. Only one or two hybrids were expected to show these desirable combinations, whereas seven have resisted all efforts to infect them with the mosaic disease, and have grown as tall as or taller than P. O. J. 2725 and arrowed later.

The following are descriptions of some of the best of the hybrids:

Mayaguez-25 is resistant to mosaic disease, germinates rapidly, grows taller than P. O. J. 2725, yields a cane of good girth, and sheds its leaves freely. In a hand mill test this cane analyzed 17 per cent sucrose and a purity of 87.6 per cent. Under tests which were carried on in cooperation with the South Porto Rico Sugar Co., at Añasco, Mayaguez-25 outgrew B. H. 10/12, with which it was interplanted. Growth of the first ratoon from the original stool was very good. The principal drawbacks to Mayaguez-25 are its medium-to-low percentage of sucrose and its reclining habit of growth.

Mayaguez-14 is resistant to the mosaic disease, produces larger canes than does Mayaguez-25, and grows very tall. In length of sugar-producing cane it exceeded the growth of P. O. J. 2725 by 3 to 4 feet at Mayaguez. Mayaguez-14 also sheds its leaves freely and stands erect. It is slightly lower in sucrose content than Mayaguez-25, and the ratoon from the first stool was not promising. Mayaguez-14 is somewhat later in arrowing than the parent P. O. J. 2725.

Mayaguez-3 is resistant to the mosaic disease, equals Mayaguez-25 in sucrose content, and exceeds both Mayaguez-25 and Mayaguez-14 in tonnage. Under irrigation at Añasco, Mayaguez-3 was outstandingly superior to B. H. 10/12 in yield of cane. The girth of cane is good and the leaves are shed freely. The cane remains erect and is not attacked by borer. Additional study is needed on the ratooning power of this hybrid before it can be recommended for general planting. Mayaguez-3 has not arrowed during the two seasons it was under test at Mayaguez.

Mayaguez-28 is resistant to the mosaic disease, makes a growth which is not quite equal to that of P. O. J. 2725, but has splendid ratooning power and appears to have a richer juice than either parent. In a hand-mill test this cane analyzed at 11 months (February, 1926) 21.98 per cent sucrose and a purity of 92.7 per cent. The leaves are healthy in appearance like those of P. O. J. 2725 and the hybrid apparently withstands drought equally well. Although Mayaguez-28 arrows early, it produces a rich juice which justifies further testing of the hybrid under varied conditions.

Several other hybrids afford good breeding material, or may be worthy of a trial in short-season regions, such as in Louisiana and in Argentina. Mayaguez-11 gives a good commercial sucrose and closes in so rapidly as to require very little cultivation. The canes are of good girth and tiller well. At 8 to 10 months this hybrid considerably exceeded the growth of B. H. 10/12 under irrigation at Añasco. Mayaguez-11 reached its maximum growth at this time and B. H. 10/12 has since outgrown it. The ratooning power of Mayaguez-11 is not known and the hybrid is not very resistant to the mosaic disease. Mayaguez-5, which produces small canes that exceed P. O. J. 2725 and B. H. 10/12 in growth and resist the mosaic disease, is promising. It is not known whether Mayaguez-5 can compete with Uba, but it ratoons well, has canes of larger girth than the latter, and sheds its leaves freely.

REPORT OF THE AGRICULTURIST

By H. C. Henricksen

PINEAPPLE INVESTIGATIONS

During the past two years an intensive study has been made of the pineapple plant to solve the various problems having a bearing on the industry in Porto Rico. Plants which were functioning normally, as indicated by outward appearances, were compared with plants showing abnormality of some kind. The plant tissues were then carefully studied in order to determine the cause of these differences, and recommendations based on the findings were made to and adopted by some of the planters at once. The investigations thus far have proved to be of immediate value to the local pineapple industry.[2]

Comparison Based Upon Outward Appearances

LEAF AREA

The leaf area of the Red Spanish variety permits accurately comparing the size of one plant with that of another. A normal plant of desirable strain, which has been grown on suitable soil and under favorable climatic conditions on the coastal plains, has a leaf area approximating 1 square foot for each month of growth, not including the outer withered leaves or the inner small ones. For example, a plant of standard size 8 months old should have 25 to 30 leaves averaging in length 35 to 40 inches and in width 2¼ to 2½ inches at a short distance above the base. A plant which falls considerably short in these dimensions when grown under the conditions mentioned may be considered undersized.

SPININESS OF LEAVES

The edges of the leaves of the Red Spanish variety are somewhat spinose and the spines are smaller in number and in size on some of the plants than on others. However, slips from plants having spiny-edged leaves may produce leaves that are nearly smooth edged, and, conversely, slips from plants having smooth-edged leaves may produce leaves that are extremely spiny. These variations have been found to be controlled by varying the food and water supply of the plants. When the supply of both food and water is ample the leaves are usually smooth edged. A shortage of either food or water is likely to result in spine formation as long as the shortage lasts. It is not unusual, therefore, to find plants bearing leaves which are spiny edged in part interspersed with sections that are smooth edged. Some idea of the past growing conditions of the plant can be formed from the spine formation, just as growth periods of a tree can be determined from the rings in the trunk.

[2] The results have been published for general dissemination in mimeographed numbers of Agricultural Notes, available copies of which may be had upon application to the director of the station.

COLOR OF LEAVES

The color of the leaves is one of the most important factors for detecting abnormality in a plant. The leaves of a normal plant are always dark green, tinged with bronze up to the time the plant blooms. A light green, yellowish, reddish, or nearly white color denotes various stages of abnormality during the growing period. The leaves usually turn rather pale green at the time the plant fruits, but not sufficiently so to make it impossible to distinguish between vigorous and less vigorous plants.

SIZE OF STALK

The plant stalk serves as a reservoir for such plant food as is to be used by the fruit, and must be above a certain size by the time the plant is ready to bloom to produce fruit of normal size. Extensive weight and measurement data show that a stalk 2½ inches in circumference, 7½ inches in length, and one-half kilogram in weight will, under favorable conditions, produce fruit of maximum size, whereas a small stalk weighing, say, 350 grams is likely to fail to do so. On the other hand, an extremely large and heavy stalk may produce a small fruit, which shows that size of stalk is not the only limiting factor in fruit formation.

NUMBER AND SIZE OF ROOTS

The root system of the pineapple plant is governed by the physical condition and chemical composition of the soil in which the plant grows and also by the number and kind of predaceous insects and parasites present. In well-drained and well-aerated soil the roots are usually stout and are sparingly branched but thickly covered with root hairs. A root system which is very different from the kind just described may be considered to be abnormal.

The number of roots present is not an infallible indication of the state of normality. However, corrective measures should be sought when a large plant is practically wanting in roots or when frayed or decayed root stumps are in evidence.

SIZE OF FRUIT AND FRUIT STEM

The size of the fruit is governed by the size of the newly formed bloom and by the development of the fruit after blooming is over. Size of the newly formed bloom depends largely upon size of the plant stalk, and development of the fruit after blooming is over depends upon growing conditions during fruit formation. The Red Spanish pineapple is usually cone shaped, although it may be nearly cylindrical. The eyes are arranged in uniform rows from apex to base. The directions of the rows deviate about 30° from the perpendicular. On the cone-shaped fruit the eyes at the base are larger than those at the apex, and the number of the circumference is 13 regardless of whether the count is made at the apex or base and regardless of the diameter of the fruit. They vary on the line from base to crown as follows: Size 12, 8 and 9 in alternate rows, sizes 16 and 18, 7 and 8 in alternate rows, and sizes 24 and 30, 6 and 7 in alternate rows,

lessening in the same scale with the still smaller sizes. This rule applies very closely for the cone-shaped types, but less so for the short, stubby types.

The diameter of the fruit stem is of considerable practical importance, for a thin stem is likely to break, rendering the fruit unfit for marketing. The thickness of the fruit stem is determined at the time the plant blooms. The portion of the plant stalk developing into fruit stem does not enlarge in diameter by subsequent growth. The planter should therefore grow vigorous plants of a desirable strain in order to avoid loss of fruit on account of weak fruit stems.

Some Causes of Outward Discernible Differences in the Pineapple Plant

Such factors as moisture content, reaction of the sap, carbohydrates, proteins, enzymes, and inorganic matter in the leaf must be studied for a determination of the causes of outward discernible differences in the pineapple plant.

WATER CONTENT

Any difference in the water content of the leaves of normal plants and the leaves of abnormal plants depends upon the cause of abnormality. In a normal leaf the approximate water content is 91 per cent in the white-leaf base, 85 per cent in the middle section, and 80 per cent in the section adjoining the apex. When growth is exceptionally vigorous, as in plants the heart of which has been burned out by inorganic salts, the water content of the middle section of the leaf may range from 92 to 94 per cent. These percentages are also common for edemaceous growth, such as is produced when the plant is treated with potassium nitrate. On the other hand, leaves of reddish color and of leathery appearance, due to destruction of some of the roots of the plant, often have a water content of less than 80 per cent. However, a chlorotic condition due to unsuitable soil conditions is not necessarily accompanied by a water shortage in the tissue of the plant. As a general rule, dry tissue is correlated with a high pH of the sap and a high protein-carbohydrate ratio, both of which factors indicate abnormality in the young leaf.

REACTION OF SAP

In the leaves of normal plants the pH of the sap is usually 6 to 6.3 in the middle section, higher toward the apex, and lower toward the base. In young, vigorous growth the pH is practically always lower than in the mature leaves. Likewise, the pH is generally much lower in the leaves of plants of vigorous growth than in the leaves of plants that are somewhat dormant or senescent. For example, a pH of 5 was observed in extremely vigorous growth as compared with a pH of 6.8 in the reddish leathery leaves of a highly senescent plant.

CARBOHYDRATES

The total carbohydrates in the leaves which are hydrolysable by 1 per cent hydrochloric acid, vary according to vigor of growth. For example, the carbohydrate content is about 13 per cent in the young

leaves of very vigorous plants, whereas it is about 30 per cent in reddish, leathery leaves, and may be as high as 40 per cent in typically chlorotic leaves, all calculated on the dry matter basis.

The distribution of the various sugars also is interesting. The leaves of normal plants contain about 0.5 per cent monosaccharide-hexoses, calculated on the fresh tissue, whereas leaves which are red, leathery, or chlorotic contain over 1 per cent. In the latter case, the leaves contain about three times as much monosaccharide-pentose sugar as the former.

The content of polysaccharides, which are hydrolysable by 1 per cent hydrochloric acid, is higher in the young, vigorous growth than in the more mature leaves, indicating that more of the cellulose is hydrolysable in the immature tissue. Of significance also is the difference in kind of hexoses present. The normal leaves contain a great deal of starch, whereas the chlorotic leaves contain but little. On the other hand, the latter are considerably higher in mucilaginous products than the former, which indicates that starch formation is inhibited in the chlorotic leaf and explains why there is a greater amount of gum formation in the latter case than in the former.

The difference in gum formation is further emphasized by the content of pentosans in the two kinds of tissue. Normal leaves examined contained only 0.36 per cent pentoses, or the corresponding amount of pentosans calculated on the fresh tissue, whereas chlorotic leaves contained over 1.08 per cent.

PROTEINS

The protein content of the leaves of normal and abnormal plants generally varies in inverse proportion to the carbohydrate content. A normal leaf usually contains about 6 per cent protein, calculated on the weight of the dry matter. This percentage may fall to 4 per cent in the leaves of senescent and chlorotic plants, and it may rise to 13 per cent in the young leaves of very vigorous plants. In the latter case the protein-carbohydrate ratio is often as low as 1, whereas in the former case it may be as high as 10 or more.

From the data at hand it appears that as long as the protein content nearly equals the carbohydrate content, the plant will make very vigorous growth. Mature leaves are in about normal condition when the carbohydrate content is three to four times as high as the protein content, but the plant begins to show signs of dormancy or senescence when the carbohydrate content of the leaves is five to six times as high as the protein, and it is either in a very advanced stage of senescence or is very chlorotic when there are 8 to 10 parts carbohydrate to 1 part protein. A high protein-carbohydrate ratio is always correlated with a low chlorophyll, and a high reducing-sugar content is correlated with a high anthocyanin content.

ENZYMES

Peroxidase is present in all parts of the pineapple plant, but the difference in content between an abnormal and a normal plant is small, and the results are not very consistent.

Oxidase is present in such minute quantities as to make its determination difficult and its importance negligible.

Catalase.—The leaves of normal plants contain three to four times as much catalase as do red and chlorotic leaves, and the results of

catalase determinations are consistent, thus offering a possible means of distinguishing normal from abnormal plants.

Reductase.—Nitrates are readily reduced by the leaf tissue of normal plants, whereas there is practically no reducing action by the leaf tissue of chlorotic plants. This fact offers a possible explanation for the difference in nitrate content between normal and chlorotic leaves. In the latter, nitrates are abundantly present throughout, whereas in the former the nitrates disappear at a few inches above the white base.

Diastase.—The diastase content of abnormal leaves does not differ consistently from that of normal leaves. Therefore its determination is valueless in studying the cause of abnormality in the pineapple plant. The diastase content of the leaf increases with its age. Mature leaves usually contain twice as much diastase at the time the plant is fruiting as they did several months earlier. Likewise, young, vigorously growing leaves usually contain only one-third or one-fourth as much diastase as they have several months later.

Effect of Fertilizer Elements on the Pineapple Plant

NITROGEN

The color of the leaf and the structure of its tissue are very much affected by the form and the combination of the nitrogen applied to the plant in fertilizers. When ammonium sulphate is used the leaves are normal in color and structure, whereas when either sodium or potassium nitrate is used the plant shows abnormalities. This difference is not due to a preference by the plant for ammonia, for results of pot experiments with sterile sand show that nitrogen is absorbed by the plant in the form of nitric acid rather than in the form of ammonia. However, on field soils where ammonia readily nitrifies and the resulting nitric acid combines with bases, nitrogen in the form of ammonia must be used. Since nitrate-nitrogen is preferred by the plant it would seem reasonable to suppose that the plant would benefit from fertilizer applications containing potassium nitrate, but this is not so. The leaves produced by such plants are edemaceous, shiny green, crooked, and twisted, and the fruit is usually of sugar-loaf shape and of pale color. Frequently no slips are formed, but when present they are few, small, and gnarled.

POTASSIUM

Potassium in considerable quantity is absolutely necessary for normal plant growth. Potassium sulphate is a suitable combination for pineapple fertilizers.

SODIUM

As has been stated, sodium nitrate is not desirable in fertilizers for pineapples. The plants utilize sodium especially when there is a shortage of potassium in the soil, but the physiological effect is not desirable. Sodium produces senescence of the tissue, inhibits normal formation of chlorophyll, and usually prevents the formation of anthocyanin, a pigment which is natural to the Red Spanish variety.

CALCIUM

Like sodium, calcium may be used to replace potassium in fertilizers for pineapple plants, but the effect is undesirable. When the plants are treated with large amounts of calcium salts and small

amounts of potassium salts they will be found to contain these elements in proportion to the application, and the leaves at an early stage of development will become spotted with white and brown.

PHOSPHORUS

The pineapple plant needs very little phosphorus for tissue building. In field experiments plants which were fertilized with ammonium sulphate and potassium sulphate and with very little or no phosphorus invariably were larger, more vigorous, and of better color than plants receiving an additional application of the latter. Similar results were obtained in pot experiments in which the plants were found to contain phosphorus in proportion to the amount applied. Phosphorus is effective in causing early maturity of the leaf tissue. The leaves of plants which are fertilized with generous amounts of phosphate begin to look old much sooner than do the leaves of plants receiving little or no phosphate. That the former actually behave like old leaves is provable by tests for nitrates, catalase, carbohydrates, and proteins.

SULPHUR

Since the various fertilizer elements in combination with sulphuric acid are uniformly suitable for the pineapple plant, and since sulphur is one of the most suitable products for rectifying certain soil defects as well as for controlling nematodes attacking the plant, the question of using sulphur in pineapple growing is of considerable importance. Plants which are fertilized with sulphates contain more sulphur than do plants which are grown without it, but the content of the tissue indicates that the need is amply met when the plant is treated with ammonium sulphate and potassium sulphate. In other words, the element sulphur is not needed when sulphates are used in the fertilizer unless the soil is very alkaline, or the colloidal matter is deflocculated, or nematodes are present in large numbers.

Practical Results

During the past two years over 100 soil samples were examined at the station and reported upon. As a result of the investigations many of the soils which were found to be unsuitable for pineapples now bear profitable crops.

Sulphur when used in large quantities to check the ravages of nematodes in two fields gave satisfactory results in one and greatly improved conditions in the other. The results indicate the value of sulphur for nematode control in pineapple fields.

Methods of measurement were formulated permitting accurate comparison of the various kinds of abnormality usually found in field-grown plants. Determination of nitrates and catalase in the leaf tissues, for example, reveals some abnormalities that are not perceptible to the unaided eye.

With the knowledge gleaned from the investigations it is possible to answer many questions of practical importance regarding pineapple growing in Porto Rico. Two questions still awaiting answer relate to the control of time of fruiting and of maturing of the fruit and to the potential difference between different plants.

REPORT OF THE PLANT PATHOLOGIST

By C. M. Tucker

STUDIES OF THE GENUS PHYTOPHTHORA

The plant pathologist was on leave of absence in the United States during most of the year covered by this report. The collection of Phytophthoras has been considerably augmented and now contains about 125 strains representing nearly all the principal hosts of this important genus. Studies on the morphology, physiology, and pathogenicity of the strains are being continued. Inoculations of a number of host plants indicate that some species are able to infect a wide range of host plants, whereas others are very restricted in this ability. Observations on the ability of strains to withstand winter conditions in the Temperate Zone show a correlation between oospore production and power to survive winter conditions. Further data will have to be obtained in this regard, however, before definite conclusions can be drawn.

Examinations of oatmeal agar cultures which were kept out of doors during the winter at Columbia, Mo., revealed the presence of oogonia and oospores in two strains of *Phytophthora palmivora*. This is believed to be the first record of the occurrence of sexual spores in pure cultures of the species. Previous workers obtained oospores in mixed cultures only and considered the strains heterothallic.

Continued observations of coconut palms which were inoculated with a strain of *P. palmivora* isolated from *Sabal causiarum* have definitely established its pathogenicity. Inoculations of 10 unwounded coconut palms from 15 to 20 years old resulted in the death of 8 palms showing symptoms typical of bud rot. Parallel inoculations of an equal number of coconut palms with a strain of *P. palmivora* isolated from a diseased coconut palm resulted in the death of 5 palms. The observations were continued 14 months after inoculation.

As a control measure the eradication of coconuts and Sabals infected by bud rot was continued under the supervision of agricultural agents from the insular department of agriculture. A number of new cases appeared during the fall of 1926. The increase was attributed to injuries which were received by the bud tissues during the hurricane of July, 1926, which enabled the fungus to reach the growing point very readily. Normally, the fungus must penetrate several leaf sheaths before reaching the growing point. Cracks in the sheaths in severe storms enable the fungus to penetrate directly.

Bryophyllum pinnatum and the avocado (*Persea gratissima*) are two new hosts of the genus Phytophthora in Porto Rico. On the former host the fungus attacks the leaves, causing water-soaked areas which finally blacken and rot. The fungus spreads from the leaves to the stems. The host is not of economic importance, and the fungus is being tested for pathogenicity to other plants.

The avocado Phytophthora was isolated from the roots of a young dying tree. The tree had been in an unhealthy condition for several months. The foliage was scanty, small, and of light green color. The leaves were wilting, and most of the roots were black and dead at the time the tree was removed. The blackening was so conspicuous as to suggest association with the chestnut ink disease of France and Italy. In some cases infection had occurred near the tips of the roots and

caused them to die back. In other cases lesions appeared on the bark at any point. The cortical and cambial tissues were destroyed, but the discoloration did not extend deeply into the wood. There was no infection of the crown or of the lower part of the trunk such as accompanies foot rot of citrus and the chestnut ink disease.

Nonseptate mycelium was seen in sections of recently infected tissue, but could not be isolated in culture media because of the presence of a Fusarium which outgrew the other organisms. The Phytophthora was finally isolated in pure culture by inoculating apples with particles of the infected tissue. The Phytophthora produced a decay of the apple tissue much like the decay caused by *P. cactorum* and was readily isolated from it. No inoculations have as yet been made with the organism. One month after the removal of the avocado tree mentioned above, a young avocado tree which was growing at a distance of about 25 feet from it began to show similar symptoms.

CITRUS ROOT DISEASE

A. S. Muller of the local agricultural college was temporarily employed to make a survey of the citrus region along the north coast of the island with special attention to the root disease which has assumed considerable importance at Garrochales, Palo Alto, Manati, and Palo Seco. At Garrochales the branches were dying back, the foliage was scant and of pale green or yellowish color, and there was more or less severe crown rot. Occasional cases of heart rot were observed. In some of the groves the diseased trees had rotted roots. These were brown and firm on the surface and the decay had extended into the wood. In some cases the disease extended as a heart rot from the roots into the crown and the trunk of the trees. Diseased trees were usually found growing in rather close proximity, giving the impression that the trouble was spreading from them to healthy trees. Disease was not found to be associated with certain soil types or with moisture conditions. In one grove the dying trees were more numerous where growth was good than where growth had been checked by a shallow soil. At Palo Alto there was considerable dying back and root decay, but in over half the cases examined the crown remained normal. At Palo Seco numerous trees were observed to be dying in a heavy loam soil. In one grove which is partly marshy, there were no fewer cases of disease in the drier than in the wetter part. Die-back of branches and rotting of roots was observed, but heart rot or gumming at the crown did not always occur.

The disease attacks trees on light, sandy soils, and also on heavy loams. Groves which are comparatively dry throughout the year as well as those on which water stands for considerable periods have lost trees showing the same symptoms—die-back of branches, scant foliage, yellowing, and root decay, with presence or absence of heart or crown rot. Grapefruit trees up to 20 years old have died. In some cases young trees which were used as replants following the removal of dead trees have succumbed. The information at hand concerning the nature of the stocks on which the diseased trees were budded is too meager to permit drawing conclusions as to the relative susceptibility of stocks.

Isolations from dying-back branches yielded in all cases a fungus closely resembling *Colletotrichum glœosporioides*. Young twigs in incipient stages of dying back were used as sources of material for isolations.

Diseased root tissue was selected at the union of diseased and healthy tissue and when plated in agar produced colonies of Fusarium in every case. Bacteria accompanied the fungus in a few instances. Isolations from diseased roots from each part of the region where the disease occurs resulted in cultures of a Fusarium, and the strains obtained from the different places are apparently identical. No evidence that the Fusarium is pathogenic has been obtained, but further investigations on the question are being carried on.

REPORT OF THE PARASITOLOGIST

By G. DIKMANS[1]

GENERAL SURVEY

The work in parasitology was begun in 1924. Examination of domestic animals during the period 1924–1926 revealed the presence of nematodes, *Hæmonchus contortus*, *H. similis*, *Ostertagia ostertagi*, *Bunostomum phlebotomum*, *Cooperia* sp., *Œsophagostomum radiatum*, *Trichuris ovis*, *Capillaria* sp., *Syngamus laryngeus*, and *Dictyocaulus* sp., in cattle; *Syngamus laryngeus*, *Hæmonchus contortus*, and *Œsophagostomum columbianum*, in goats; *Crassisoma urosubulatum*, *Hyostrongylus rubidus*, *Œsophagostomum dentatum*, *O. longicaudum*, *Ascaris lumbricoides*, and *Arduenna strongylina*, in pigs; *Tetrameres fissispinus*, *Subulura strongylina*, *Ascaridia lineata*, *Heterakis papillosa*, *Capillaria annulata*, and *Cheilospirura hamulosa*, in chickens; *Heterakis brevispiculum*, *Dispharagus spiralis*, *Ascaridia numidæ*, and *Subulura strongylina*, in guinea hens; *Subulura brumpti*, in turkeys; *Ancylostomum* sp. in the cat; and *A. caninum*, *Ascaridæ* sp., and *Trichuris depressiusculus*, in the dog. Trematodes, *Fasciola hepatica*, were found in cattle; *Posthormostomum commutatum*, in chickens; *Prosthogonimus* sp., in the duck, and *Platynosomum fastosum*, in the cat. Acanthocephala, *Macranthorynchus hirudinaceus* were found in pigs, and *Corynosoma* sp. in the cat. Cestodes, *Davainea tetragona*, were found in chickens; *Tænia crassicollis* and *Diphyllobothrium mansoni*, in the cat; and *Dipylidium* sp. and *Tænia marginata*, in the dog.

The external parasites attacking domestic animals in Porto Rico include *Hæmatopinus eurysternus* (Lajas), *Boophilus annulatus* var. *caudatus* (Mayaguez), and *Hæmotobia serrata* (San German) for cattle, *Linognathus* sp. (Mayaguez) and *Boophilus annulatus* var. *caudatus* (Mayaguez) on goats, *Psoroptes communis* in the skin scrapings from a horse (Guayanilla), *Rhipicephalus sanguineus* and fleas on dogs (Mayaguez), and *Echidnophaga gallinacea* on chickens (Guanajibo Mayaguez).

Lice and mites should be effectively controlled wherever dipping vats are available.

Post-mortem examination of a chicken showed one kidney and ureter greatly enlarged. These were submitted to the pathological division of the Porto Rican School of Tropical Medicine, the director of which called the attention of the parasitologist to the presence of trematode eggs in sections of the kidney. The trematode was not found.

It is of interest to note the finding of *Syngamus laryngeus* in the goat. The nematode has been reported in cattle in Porto Rico,

[1] Transferred to Bureau of Animal Industry, U. S. Department of Agriculture, June 8, 1926.

Bagué (1921), but so far as it is known this is the first record of finding the parasite in goats, unless *Syngamus nasicola* Von Linst (1899) is considered to be identical with *S. laryngeus* Raillet (1899). Chapin in 1925 showed that these species are very probably identical. *Œsophagostomum longicaudum* was found in pigs in New Guinea by Goodey of the London School of Tropical Medicine. The parasite apparently is widely distributed over the world. *Subulura strongylina* has been found in chickens and various other kinds of birds in Brazil but has not been previously reported as a parasite of guinea fowls. *Heterakis brevispiculum* is apparently frequently present in guinea fowls in Dahomey and Belgian Congo, Africa, and more recently has been reported from Brazil. *Ascaridia numidæ* is known as a parasite of guinea fowls in Africa. *Heterakis brevispiculum* and *Ascaridia numidæ* in the guinea fowl and *Subulura strongylina* in chickens and the guinea fowl have not previously been reported from the United States. However, since comparatively few domestic fowls were examined, the data obtained are insufficient to permit drawing general conclusions. In general the parasites attacking cattle in Porto Rico are similar to those molesting these animals in the continental United States. A survey of the distribution and prevalence of animal parasites in Porto Rico should be of decided interest. With the exception of the rather frequent finding of *Crassisoma urosubulatum*, the internal parasites of pigs in Porto Rico presented no novel features. *C. urosubulatum*, however, in view of its relationship to the general group of Ankylostomidæ may prove to be of paramount importance. Studies of the prevalence and distribution of the parasite should be made.

The fluke *Posthormostomum commutatum* has been reported as a parasite of the chicken, turkey, guinea fowl, and pigeon in Italy and Tunis, but is reported here for the first time from the United States. *Platynosomum fastosum* of the cat appears to be common in Brazil, but is reported here for the first time from the United States.

The parasitologist gratefully acknowledges his indebtedness to the experts of the Division of Zoology, Bureau of Animal Industry, United States Department of Agriculture, for their courtesy in identifying many of the parasites mentioned in his report.

REPORT OF THE PARASITOLOGIST

By H. L. Van Volkenberg

The parasites collected during 1927 which were heretofore unreported for Porto Rico are as follows: Of the internal parasites, the nematodes are *Filaria labiato-papillosa*, from abdominal cavity, and *Onchocerca* sp., from ligamentum nuchæ, in cattle; *Synthetocaulus capillaris*, *Trichuris ovis*, *Chabertia ovina*, and *Œsophagostomum venulosum*, in goats; and *Metastrongylus elongatus*, *M. brevivaginatus*, *Stephanurus dentatus*, *Trichuris suis*, and *Necator suillus*, in swine; Protozoa, *Eimeria zürni*, in cattle; trematodes, *Paramphistomum cervi*, in cattle; *Fasciola hepatica*, in goats and swine; cestodes, *Moniezia alba*, in cattle; *Tænia* sp. and *Cysticercus tenuicollis*, in goats; *C. cellulosæ* and *C. tenuicollis*, in swine; and of the external parasites, *Ornithodores meginini*, *Demodex folliculorum*, and *Hypoderma* sp., in cattle; *O. meginini* and *Trichodectes* sp., in goats; *Dermacentor nitens* and *Dermatophilus penetrans*, in swine; *D. nitens* and *Trombicula* sp., in horses; and *Gonioco-*

tes gigas, *Menopon pallidum*, *Lipeurus* sp., *Cnemidocoptes mutans*, *Dermanyssus gallinæ*, and *Trombicula* sp., in chickens.

The leading projects under investigation include (1) a general survey of the parasites affecting domestic animals in Porto Rico; (2) a study of the liver fluke and its relation to disease in cattle, goats, and swine; (3) a study of the life history and economic importance of *Stephanurus dentatus*; and (4) the possible relation of *Necator suillus* to the problem of human ankylostomiasis in Porto Rico.

GENERAL SURVEY

The first project has received the most attention. The bulk of the material has been obtained from the local abattoir. Approximately 100 sets of viscera of cattle, goats, and hogs have been systematically examined to determine the species of parasites, the percentage infested, and the importance of the parasites collected. In addition, data have been recorded for publication later, of the examination of fecal material, skin scrapings, etc., of animals in this vicinity and at distant points on the island.

The studies made so far indicate that the most serious parasites attacking cattle, arranged tentatively according to their economic importance, are stomach worms, Texas fever ticks, liver flukes, nodular worms, lung worms, mange mites, coccidia, flies, and lice.

The seriousness of stomach worms and also nodular worms has forced cattle raisers in certain localities to keep their animals in board-floored pens elevated above the ground, occasionally cement-floored pens, and to feed them by hand until they were several months old. Even so, fecal examination of these calves which had never been on pasture has shown that many are infected and some heavily, demonstrating that these parasites can be picked up in pens, which are theoretically regarded as being parasite proof. Apparently infective larvæ have been carried to the pens on grasses cut from fields which had been fertilized with stable manure, and a heavy reinfection may have occurred as a result of insanitary conditions in the pens. However, healthy calves are being successfully raised by several dairymen in the heavily infested districts by keeping the animals off pasture until they become 8 to 12 months old and dosing regularly, once each month, with a solution of copper sulphate.

An unidentified filarial worm, attached to the cervical ligament, has been found in over 80 per cent of the cattle examined. The parasite apparently is of no pathogenic importance.

Of the external parasites, the cattle tick is widely distributed and carries tick fever as elsewhere. The spinose ear tick has been collected from several cattle. A large sucking louse is common and is found, together with the eggs or nits, in the switch of the tail and occasionally, especially in a heavily infested animal, among the long hairs on the inner edge of the ears.

The mange mite, *Demodex folliculorum*, has been identified from the scrapings taken from a cow near San Juan and a calf at Mayaguez. Larvæ of an ox warble fly were seen on three cows which were recently imported from the States.

Evidently conditions are unfavorable to the fly, as the larvæ are often imported on cattle and reinfestation is not known to occur.

Very few data have been obtained on the losses in swine due to parasitic infestation. However, parasites probably partly account for the many stunted and emaciated animals which have been frequently observed.

Dikmans, in a former report of the station,[4] gives the results of a systematic examination of the small intestines of 60 pigs. Of internal parasites, lungworms were found in over 50 per cent and lardworms in over 40 per cent of the animals. *Cysticercus cellulosæ*, the larval stage of *Tænia solium*, a dangerous tapeworm in man, was found in two hogs slaughtered at the abbattoir. Both animals were heavily infested.

Of the ectoparasites, the sand flea, locally known as "nigua," is common in pigs which are raised near the seashore. The flea burrows into the skin above and between the claws and sometimes causes considerable inflammation. The tropical horse tick was found in the ears of two pigs.

Very little is known regarding the seriousness of parasites affecting goats. Stomach worms were found in about 75 per cent of the goats examined. Apparently the adult native goat is less resistant to stomach worm infestation than are cattle, and the kid is more resistant to the resultant bad effects from infection than are calves. The goat should be considered as an important factor in the dissemination of stomach worms, as the same species occurs in both goats and cattle.

Nodular worms were found in over 70 per cent and whipworms in about 30 per cent of the goats examined. Lungworms and liver flukes were common. *Syngamus laryngeus* is much more common in goats than in cattle and the number of parasites per animal is usually much greater in the goat. A few specimens of *Chabertia ovina* were recovered from a goat which had been recently imported from the States.

Of the two species of lice which had been found on goats, the biting louse is the more common. The goat as a carrier of cattle ticks must be taken into account if eradication of this parasite is attempted. Spinose ear ticks were found on several goats.

Some study has been made of the external parasites of horses. Psoroptic mange has been found in three widely separated localities. One of these findings was made by Dikmans. This and reports by laymen indicate that this form of mange is widely distributed. The tropical horse tick was collected from several horses at Mayaguez. The larvæ of a trombidium mite has been found attacking the face and head and occasionally the body. This mite is very common in this vicinity, especially during the wet season. The irritation caused by it is very great, especially in thin-skinned horses. Affected animals have a characteristic appearance in which hair in numerous small spots is lost from rubbing, but the crusts, scales, and thickening of the skin, distinctive of some manges, are absent.

The dermatitis of both horses and cattle caused by mites, lice, and bacteria will require considerable study, as these forms of skin diseases are common and serious in Porto Rico and very little is known concerning them.

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[4] Dikmans, G. REPORT OF THE PARASITOLOGIST. Porto Rico Agr. Expt. Sta. Rpt. 1925: 22, 1927.

LIVER FLUKES

The study of the liver fluke is not completed. Several species of fresh-water snails were collected and examined for the purpose of finding the intermediate host. An endeavor is being made to carry out part of the life cycle of the parasite in the laboratory. Uninfected snails are being infected with the miracidia from the eggs of the liver fluke, and the cercariæ thus produced in the snail will be in turn transmitted to experimental animals. The cercariæ from snails taken in the field are also being transmitted to animals. A study will be made with the view of controlling this parasite either by medicinal treatment of infected animals or by destroying the snail in the field, or both.

SWINE KIDNEY WORM

The study of the life history of the kidney worm, *Stephanurus dentatus*, of swine has indicated that infection is direct and that the larvæ undergo a stage of development in the liver of the pig before passing to the fat surrounding the liver and kidneys.

HOOKWORM OF SWINE

The study of the hookworm, *Necator suillus*, of swine has been handicapped by the lack of material. A systematic examination of intestines from over 100 pigs disclosed a light infestation in only 2 instances. This indicates that the parasite is not common, at least in the vicinity of Mayaguez.

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PORTO RICO AGRICULTURAL EXPERIMENT STATION
MAYAGUEZ, P. R.
Under the supervision of the
UNITED STATES DEPARTMENT OF AGRICULTURE

REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION

1928

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Issued December, 1929

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PORTO RICO AGRICULTURAL EXPERIMENT STATION, MAYAGUEZ

[Under the supervision of the Office of Experiment Stations, United States Department of Agriculture]

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WALTER H. EVANS, *Chief, Division of Insular Stations, Office of Experiment Stations.*

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PORTO RICO AGRICULTURAL EXPERIMENT STATION
MAYAGUEZ, P. R.

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Washington, D. C. December, 1929

REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION, 1928

CONTENTS

REPORT OF THE DIRECTOR

By D. W. MAY

The work of the station during the year, as described under the several departments, proceeded unhampered. Investigations in production in the several lines of agriculture included both plant and animal life. There were no changes in personnel, and the position of entomologist continued to remain unfilled. Apparently it becomes increasingly difficult to secure investigators in certain lines of agricultural research.

IMPROVEMENTS

During the year an addition was made to the east wing of the main building, and the library was moved into it. This now permits the use of three rooms for library purposes and more than doubles the space formerly occupied. A trained librarian was secured to index and classify the library and place it on a modern basis. The usefulness of the library to the personnel of the station and to others has been thus greatly increased.

The tiling system whereby the low grounds of the station are drained was installed 25 years ago. The outlet is through a 4-foot

tunnel emptying into the river. At this point the river bends and cuts into the field. The steady encroachment of the water made it necessary to construct a buttressed mouth to the tunnel and an abutment to shift the current from the field. The material used represented a large outlay of money. The labor was done by the permanent employees of the station during such times as they could be spared from the field.

The station lies along the Yaguez River opposite the city of Mayaguez, and between two asphalted roads which cross the river. The only connecting road between these two roads passes through the station property. The traffic over this road is growing rapidly, and the cost of maintaining it with a gravel surface proved to be increasingly high. Moreover, the dust raised by passing vehicles was detrimental to the work of the station. This road was therefore asphalted and now has a better surface of a more permanent nature than formerly. The Department of the Interior kindly loaned the road roller, vats, and other implements necessary for carrying on the work, which was done by employees of the station.

On the mountain side, 2½ miles distant, where the station has planted a 200-acre plat with forest trees, there is a never-failing spring of clear, pure water. During the year 2½-inch galvanized piping was laid from the spring to the station to convey the water to the station homes, laboratories, stables, and plant houses. The spring has contributed greatly to the success and efficiency of the work of the station and the well-being and health of the personnel. The system is operated at a saving to the station of about $600 per annum.

Composition of the water.—A sample of the water when analyzed had a composition as follows:

TABLE 1.—*Composition of spring water on the mountain above Mayaguez*[1]

Constituents	Per liter	Constituents	Per liter
	Mgms.		*Mgms.*
Total solids	128.00	Potash (K_2O)	[3]
Total solids after heating	92.00	Nitrogen as ammonia (NH_3)	0.80
Silica (SiO_2)	29.00	Nitrogen as nitrates (NO_3)	[3]
Ferric oxide (Fe_2O_3)	1.30	Chlorine (Cl_2)	[3]
Lime (CaO)	28.90	Sulphates (SO_3)	2.50
Magnesia (MgO)	7.30	Carbonates (CO_2)	[3]
Soda (Na_2O)	3.00	Bicarbonates (HCO_3)	[3]

[1] Reaction, slightly alkaline to phenolphthalein.
[2] Traces.
[3] Undetermined.

CATTLE

Cattle were probably brought to the island shortly after its discovery. They were likely shipped in from southern Spain and were good individuals of their type. Their descendants still show characteristics of the cattle of the southwestern provinces of the peninsula. Porto Rico is naturally adapted to cattle raising, and early importations must have thrived so well that further improved blood was not introduced for some time. However, during the nineteenth century some other kinds of improved cattle are reported to have been introduced, and, in fact, indications of such a breed are visible in the cattle of certain districts. Many of the cattle about Guayama,

for example, show undoubted evidence in the ears, dewlap, and shoulder hump of Zebu blood, and the red cattle about Arecibo show evidence in conformation of Shorthorn and Devon blood.

The station has been engaged in importing and breeding cattle in Porto Rico for 25 years. The results of some of the experiments have been of value in present practice and will serve as guides for the future. In 1904 the station brought in three males and one female, all Herefords, in the hope of making crosses for the improvement of the cattle for use as work and beef animals, as is done on the western ranges in the States. These cattle did not thrive as did the native animals. The hot sun and the cattle tick militated against their acclimatization. The station then imported from Texas four Zebu grade bulls the sires of which were purebred Zebus, and the dams showed some Hereford and Shorthorn blood. The animals

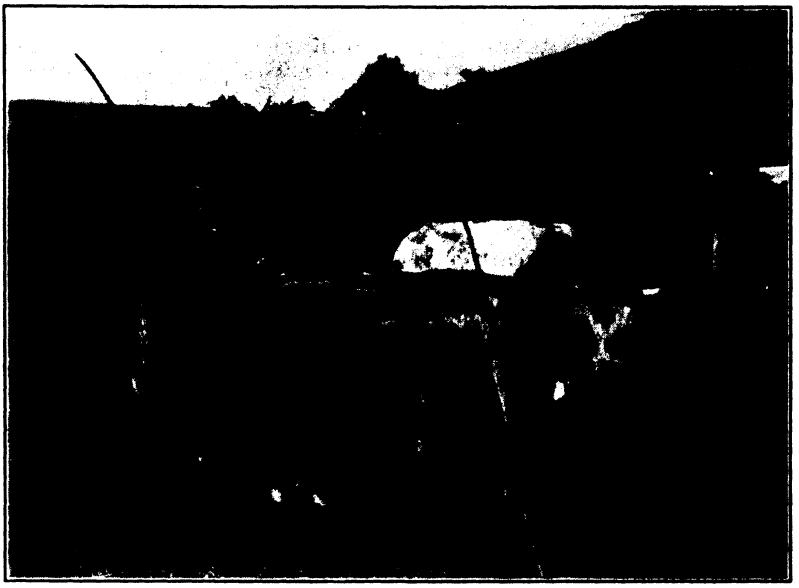

FIGURE 1.—Shorthorn bulls at the yoke

were perfectly hardy in Porto Rico and their progeny showed improvement as work animals. The introductions did not improve the beef type, and lessened the desirable quality of milk production. A wildness, quite different from that of the cattle of the island, proved to be their outstanding characteristic.

The station has imported at different times Shorthorn cattle mainly for crossing with native cattle. (Fig. 1.) These introductions greatly improved the stock in various parts of the island, as at Dorado and Guánica. This Shorthorn blood persists and its favorable influence on the herds in Porto Rico adds to its prestige in improving form, hastening maturity, and increasing milk yield.

Probably a larger number of Holsteins than of cattle of any other breed have been imported into Porto Rico. These were brought in because of their high average milk yield. Their acclimatization has been difficult.

Channel Island cattle, the Jerseys and the Guernseys, largely of pure blood, have been introduced. In the main they have done well and have proved to be adapted to the climate. Their short hair affords less protection for the cattle tick. Of the two breeds, the Guernsey is the larger and, therefore, better adapted to work purposes. Again, of all the improved breeds, the Guernsey is nearest to the type of the cattle that may be said to be native to Porto Rico, and it makes the best crosses without undue variations or reversions.

Porto Rico should have only one breed of cattle as have the islands of Jersey and Guernsey. Upon this breed should be built a race of island cattle that will be adapted to the environment and can be bred to the native cattle for improvement in milking qualities and for maintaining ability to work, the two leading requirements in cattle at present. The station recommends the Guernsey as the best general-purpose cattle for island conditions.

The safest way to improve the cattle is by introducing purebred sires of breeds that are best adapted to local needs. The native cattle are strong, vigorous, and of good size. That they have kept their size and quality through several centuries of unscientific breeding is due to the favorable climate and nutritious grasses of Porto Rico. Improvement in crossbreeding is due to the large, robust frame of the cattle and to their climatic adaptability.

The introductions during the past five years included in 1923–24, 620 cattle valued at $71,409; in 1924–25, 1,261 cattle valued at $129,350; in 1925–26, 1,503 cattle valued at $157,622; in 1926–27, 2,184 cattle valued at $212,945; and in 1927–28, 1,258 cattle valued at $123,820. These animals were for breeding purposes and were purebreds or high grades of their respective breeds. The number indicates the acceleration given in late years to the work of improving the cattle of the island.

Comparison of native with grade and purebred cows.—That the cattle of Porto Rico may be improved by crossing them with purebreds is shown by the results had with the station herd. The station started a herd with five native cows (fig. 2) and a Guernsey bull. A new purebred bull was purchased as needed to avoid inbreeding. Crossbreeding resulted in the development of half-breds which when bred to purebred bulls produced three-quarter breds. These in their turn produced seven-eighths, and the next generation fifteen-sixteenths breds. The natives gave 2,953 pounds of milk per year, the half-breds, 4,344 pounds, and the three-quarter Guernseys, 4,928 pounds.

In 1923 three purebred Guernsey heifers were added to the herd. By 1928 their female progeny had increased to 15 head, and the males were sold. The last of the grade females were sold in 1928, leaving the station with a purebred registered herd.

Increasing the milk production.—The price of milk in Porto Rico is excessively high. This is due to low average yields and the cost of concentrates which are imported. The first difficulty can be overcome by improving the breed, and the second by planting such grain feeds as are adapted to the island. Some root crops, such as the sweetpotato, might be grown also for feeding. Yields of 15 tons of sweetpotatoes per acre have been produced at the station. Mill feeds continue to be imported because no small grains are grown

here. Some corn is grown, but much of it is imported for human consumption and often at less cost than native corn can be had. The station has at different times distributed several tons of seed of kafir, milo maize, and feterita. Though these grow well, especially in regions where the rainfall is deficient, none of them have found sufficient favor with the local farmers to warrant further planting. In addition to the malojillo and guinea grasses, which have been grown for range improvement for many years in Porto Rico, the elephant and Guatemala grasses imported by the station are extensively grown also. Uba cane is satisfactory for sugar production on some lands and yields large amounts of forage in all sections of the island. A successful legume is needed that will furnish protein in the ration

FIGURE 2.—Native cow

and at the same time increase the nitrogen content of the soil. The cowpea or "frijol," as it is locally called, produces well on most soils. The soybean has not become established. Many legumes new to the island have been tested at the station. For general purposes, including soil improvement and use as a feed, the velvetbean succeeds best and over the widest area.

CLOVERS AND ALLIED PLANTS

Clovers and allied plants afford feed for livestock and also improve the soil by storing therein nitrogen from the air. They are found in any well-grounded system of agriculture in the Temperate Zone. The clovers and allied plants under trial at this station from 5 to 20 years include red clover, mammoth trefoil, Lespedeza, sweetclover, alfalfa, bur, subterranean, crimson, and white clovers. None of these have grown successfully from the first plantings of the seed, or established themselves by reseeding. The seed has been inoculated with the proper bacteria in every instance, and nodules have formed

on the roots. However, growth has been poor, and in most instances the plants have failed to come to maturity.

A clover crop to succeed must overcome the grasses that spring up with it, or must grow on the same soil with them. In the latter instance, the clover should grow at least as high as the grasses to maintain its place in the sun. As the local pasture and forage grasses are rank-growing, clovers maintain themselves with difficulty, especially during the seasons of heavy rainfall. Therefore, under island conditions the successful legume must be cultivated or else make such rank growth as to overcome the grasses by overtopping and smothering them out.

VELVETBEANS

The velvetbean is native to the Tropics. It was first cultivated as an ornamental. The legume, both vine and seed, makes an excellent feed for livestock, and it has therefore become of great economic importance.

The station has been growing and distributing the velvetbean for 20 years. The first variety tested was known as the Black Bengal. A number of others, differing in color and size of seed and length of vine, have been received for trial. Occasionally a variety will come back with a new name. In the Tropics a quick-maturing variety is not as desirable as in the States. The most forage in the shortest time is the goal. The variety known as Hundred Day will not mature in that length of time here, although it has produced 9 tons of green matter per acre in 100 days. The bunch velvetbean will not hold true to form in the Tropics, but spreads out into vine, showing that its tendency to grow into bush form is not fixed.

On cut-over lands that for years have been unproductive in the station forest plantation, the velvetbean alone, of the many annual legumes tried, gave a large yield. Even the cowpea failed to produce satisfactorily. The velvetbean has also proved to be very valuable in ridding land of nut grass. It is almost impossible to eradicate this pest, once it takes possession of an area, and it may cause the farmer to abandon his farm. Velvetbeans when grown on nut-grass-infested areas at the station completely smothered it out.

Velvetbeans grow well on beach lands where sand largely predominates, and on the clay soils of the interior. They make excellent cover crops on the coconut soils of the coast, crowding out weeds and smothering grasses. They do well in citrus orchards and, while the vine may cover trees to their detriment, it can be easily pruned back with a machete. Velvetbeans may serve a threefold purpose, being used (1) as an ornamental to cover an unsightly object, (2) to add nitrogen to the soil, and (3) to produce forage and grain for feed.

Velvetbean seed is hard to harvest. Harvesting should be done on a rainy day if possible. Prior to planting, the pods need only be broken in two. Local growers should harvest their own seed, since it can not be bought on the island. Seed on hand offers an inducement to the possessor to plant, and planting can be done here during any time of the year. What would be otherwise waste places may be kept growing velvetbeans at a profit.

Velvetbeans when planted on ground for the first time should be inoculated; after that inoculation is not necessary. About 15 pounds

of seed are required per acre. Fertilizing the crop will not pay. Velvetbeans when inoculated take nitrogen from the air, and they make such vigorous growth as to be able to wrest the needed potash and phosphorus from the soil.

As a feed, velvetbeans rank well with cottonseed meal, a highly nitrogenous feed. They contain a high percentage of fat. When the size of the crop permits, the beans can be crushed and the fat extracted for various uses. The residue can be fed to livestock.

At the station no insect has been found attacking the velvetbean.

UBA CANE FOR FORAGE

Although Uba cane is being supplanted by new seedlings which give a greater tonnage of sugar and are also immune to mosaic disease, it is one of the most valuable of the forage crops tried at the station. (Fig. 3.)

Yields of this cane will run well over 50 tons per acre the first year, and the ratoon crop over 40 tons. In nine months on hill land 33 tons per acre have been obtained.

Uba cane may be fed at any stage of its growth. When it is ripe or nearly so and the stalk has hardened, the cane should be run through a cutter. Cattle ate 80 per cent of fully ripe Uba cane which was cut into 1-inch lengths. Results of experiments indicate that Uba cane and velvetbeans are the greatest producers of the two types of forage—carbohydrate and leguminous—that have been tried at the station. In the latter instance, velvetbeans may be planted with the cane in the stubble remaining after each cutting.

SURINAM TOAD

The giant toads (*Bufo marinus*) which were introduced into the island five years ago have greatly increased in number and have been shipped to all parts of the island in lots varying from 10 to 1,000. Reports indicate that they are proving to be effective in controlling the changa, or mole cricket, the worst insect pest on the island. An examination of the stomachs of the toad disclosed the presence of other predacious insects also, including ants, grubs, and cockroaches.

FERTILIZERS

For several years the value of the fertilizers that have been imported into Porto Rico has approximated $3,000,000 annually. They have been used mainly on cane, but also on fruit and tobacco, and their use has been profitable. As is stated elsewhere in this report (p. 16), certain mixtures can be profitably employed in the coffee plantation.

Table 2 shows the value and kind of fertilizers imported into Porto Rico from the United States and from foreign countries during the past five years.

TABLE 2.—*Kind and value of fertilizers imported into Porto Rico during the period 1923–1928* [1]

Source and period of introduction	Nitrate of soda		Sulphate of ammonia		Chloride of potash		Sulphate of potash	
United States:	*Tons*	*Value*	*Tons*	*Value*	*Tons*	*Value*	*Tons*	*Value*
1923–24	1,095	$57,420						
1924–25	2,185	118,618						
1925–26			9,213	$511,890				
1926–27	2,809	155,596	29,375	1,615,363				
1927–28	2,527	129,102	33,858	1,502,632				
Foreign countries:								
1923–24	1,988	85,399	(2)		1,452	$52,809		
	1,087	12,374			4,222	186,552		
1924–25			100	4,725	2,924	97,117	669	$28,946
			4,151	229,816			966	47,700
1925–26	1,544	76,375			2,963	95,558	2,926	122,948
	4,007	238,279					1,670	70,907
1926–27					2,365	76,660	4,113	181,447
							18,767	462,777
1927–28					3,010	108,995	3,101	172,318
							37,163	627,430
Total	17,242	873,163	76,697	3,864,426	16,936	617,691	69,375	1,714,473

Source and period of introduction	Bone phosphate		Mixed fertilizer		Total	
United States:	*Tons*	*Value*	*Tons*	*Value*	*Tons*	*Value*
1923–24			16,675	$784,690	65,643	$3,027,002
			47,873	2,184,622		
1924–25			4,861	220,051	48,658	2,217,662
			41,612	1,878,993		
1925–26			12,586	422,373	57,878	2,324,883
			36,079	1,390,620		
1926–27					62,186	2,898,701
			30,002	1,127,742		
1927–28			21,271	731,042	57,656	2,362,776
Foreign countries:						
1923–24	600	$21,695			9,559	363,038
	210	4,209				
1924–25	166	7,290			9,657	436,261
	681	20,667				
1925–26	506	16,933			13,616	621,000
1926–27					25,245	720,884
1927–28					43,274	908,743
Total	2,163	70,794	210,959	8,740,403	393,372	15,880,950

[1] According to Customs declarations.
[2] Sulphate of ammonia imported from a foreign country is subject to a duty of $5.50 per ton.

During the last fiscal year there was a tendency toward the use of fertilizer of lower value. This is a mistake, especially when one considers that the cost of freight on fertilizer, practically all of which is imported, is $3.40 per ton, and that the cost of bagging and marketing is the same for low-grade goods as for high. True economy here means the use of the least filler possible. Fertilizer for use in the coffee districts in the mountains is subject to another heavy charge for transportation thence on pack animals. Concentrated fertilizers are therefore advisable for the Porto Rican trade.

The station again advises the employment of all such local fertilizing materials as manure, tobacco stems, wood ashes, and vegetable débris. The caves of the island which have been surveyed and mapped by the station are still found to contain many valuable deposits of guano that should be utilized as fertilizer. In some of the caves the annual deposits of bats are considerable, and the owners should regard the possession of them an asset to their farms.

VEGETABLE GROWING

In a country of equable temperatures and no frost, where the rainfall is abundant or irrigation is possible, conditions apparently should be ideal for growing vegetables throughout the year. In the

FIGURE 3.—Uba cane; fifth ratoon

Tropics, however, the greatest pests and plagues are likely to overtake and destroy the crops. Freezing in winter in the colder regions does something for the soil that can not be done for them in the

Tropics. Again, in the Temperate Zone plantings can be made in time to avoid attack by insect and fungus pests, which are always present in the Tropics.

Other conditions differing from those of the Temperate Zone affect the growing of vegetables in the Tropics. Sweet corn, for example, will rapidly pass through all the processes of growth in Porto Rico, but produce only a dwarf plant with an embryonic ear. This peculiarity is apparently due in part to the shortness of the tropical day, but it represents the difference between success and failure.

The soil is the basis of successful planting, and before it can be used for garden purposes it must be well prepared and fertilized It will then grow most of the vegetables that are produced in the North. The grower must be ready to fight insect and fungus pests from the time of sowing the seed to the time of harvesting the resultant crop, and even then the plants may be overtaken by an unexpected plague.

To grow the white potato successfully the soil should be friable and the plants well fertilized. They will grow quickly and bear tubers, but will not flower. The planted piece will often sprout, grow, and produce, yet remain hard and firm in the ground and not rot. Even the cut surface will be found not to have become discolored or soft. The potato will grow rapidly here, but will not form as large tubers as in the North. The largest yields at the station were made by Irish Cobbler, which produced 164 bushels per acre, and by Red Bliss, which produced 145 bushels per acre. The varieties were planted February 16 and dug May 19.

Of other root crops, the carrot is of easy growth and has no serious insect pests. Turnips are a success, but they should be grown quickly because they soon turn bitter. Young beets are subject to attack by leaf-eating insects. The tops should be dusted with arsenicals. After the plants are well started they will grow rapidly.

Certain parts of Porto Rico are well suited to onion growing. From them profits of $400 per acre have been reported. The greater part of the onions consumed in the island are imported. Porto Rico should supply the home demand and have a balance for export, especially of the large, mild type. They should be grown from seed, and be well fertilized, and intensely cultivated.

Peas are so easily cultivated that they should be found growing in every garden through most of the year. Both the edible and the ornamental kinds grow well, although the soil must be inoculated when they are planted therein for the first time. With later plantings this is not necessary. No insects have been found attacking the foliage at Mayaguez.

Of the salad plants, lettuce, mustard, and parsley grow most easily and are freest from insect attack. Celery also is grown easily, but it lacks the crispness of that grown in the North.

Chard and kohlrabi thrive, but the leaves of the former when young are attacked by beetles. The plants should be dusted with air-slaked lime.

Cauliflower does not head well. Until methods of overcoming this difficulty are determined, its planting is not advised. Cabbages can be grown, but they do not make as large heads as in the North. Commercially, cabbage can be imported more cheaply than it can be grown.

Certain varieties of tomatoes can be grown successfully. The Marglobe is at present the most promising variety. (Fig. 4.) Tomatoes should not be grown two years in succession on the same plat of ground.

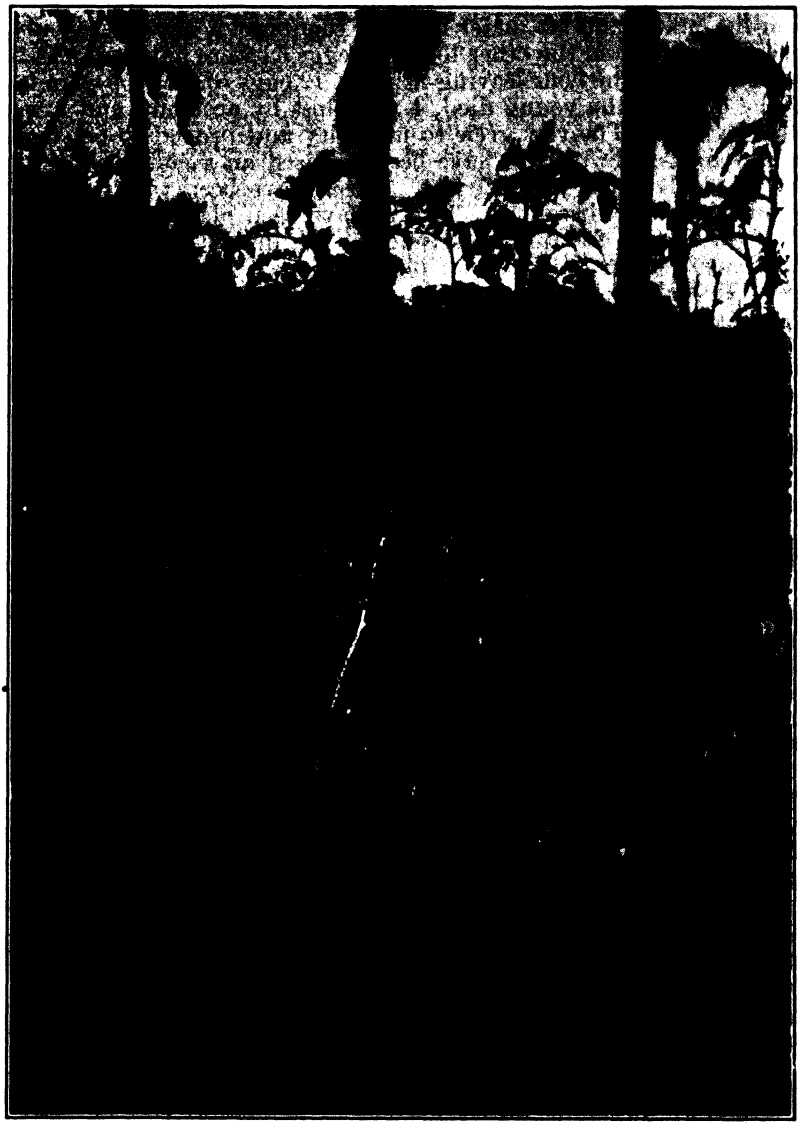

FIGURE 4.—Marglobe tomatoes

Occasionally fine melons are grown in a locality which has not previously been planted with them for some time. This encourages attempts to grow them a second time on the same area and results in failure. Insect and fungus pests destroy the crop at the second plant-

ing on the same ground. These are so persistent or so destructive as to continue notwithstanding a reasonable amount of spraying.

PHEASANTS

In May two lots of eggs of ring-necked pheasants were received from the States and set under hens. From one lot of 60 eggs only 2 were hatched; from the other lot of 50 eggs 32 were hatched. As the result of one of the hens leaving her nest 12 eggs of this lot were lost. Of the 34, 3 of the young died, 4 were lost by accident, and 2 were killed by rats. The rest grew to maturity and proved to be strong, healthy birds. Two pairs have been released on a coffee plantation where the elevation is 2,500 feet. Seven have been released in the neighborhood of Mayaguez. Twelve have been placed with employees of the station for further breeding work in captivity. Results of experiments so far indicate that pheasants may be successfully raised here. Probably the most serious menaces to their increase in the wild state are the rat and the mongoose.

REPORT OF THE ASSISTANT CHEMIST

By J. O. CARRERO

MANAGEMENT OF CANE SOILS

Results of field experiments on the utilization of nitrogen by cane soils, as reported in 1927, failed to show definite gains in tonnage for plant cane when nitrogen in the form of leaves and trash was added to the crop, whereas a gain was shown by the first ratoon crop. In the first instance the leaves and the trash were buried, and in the second instance they were left on top as a mulch.

Further studies were made to determine (1) the rate of decomposition of the trash, and (2) the effect on the disappearance and reappearance of soil nitrates. The first was accomplished by adding mixed air-dried green and dead cane trash to soils in such proportion as would be applied in the field, conditions as to other fertilizer ingredients being changed to correspond with those used in field trials. This experiment was carried on along two lines, (*a*) to determine the effect on the decomposition of trash of the different treatments applied as shown by the amount of carbon dioxide evolved, and the content of nitrate nitrogen in the soil at the close of the experiment; and (*b*) to permit of making weekly tests for the nitrate-nitrogen content of soils in beakers which had been subjected to similar treatments.

A test was made to determine the difference in rate of decomposition of green and dry trash and a mixture of the two, and the effect of adding lime. Two hundred grams of finely ground air-dried soil was thoroughly mixed with 2 grams of air-dried green and dead cane trash and placed in a 500-cubic centimeter Erlenmeyer flask. Sufficient water was added to maintain the optimum moisture content of the soil. Eight different treatments were used. The quantity of carbon dioxide produced in the flasks during 31 days and the nitrate-nitrogen content of soil samples at the end of the run were determined.

Carbon dioxide production was increased considerably by the addition of the cane trash and further increased by the addition of lime. Green trash decomposed more rapidly than the dry trash or a mixture of the two, regardless of whether the soil was limed or not. Determination was made of the nitrates present in the soil. Unlimed soil showed 31.3 parts per million nitrogen as nitrates, and soil plus lime, 52 parts per million, whereas the rest of the flasks revealed only traces. Thus decomposition had not progressed sufficiently in 31 days to allow nitrification.

A second experiment was carried on to learn the effect on decomposition of (1) adding nitrogen as nitrates, (2) mixing the trash with the soil, and (3) leaving the trash on top as a mulch.

Again the addition of trash was followed by greatly increased carbon-dioxide production showing rapid decomposition of the trash. A more active rate of decomposition followed upon the addition of lime. The addition of nitrogen was not followed by increased carbon-dioxide production, probably because only 30 parts per million nitrogen as nitrates was added. This represents an addition of only 0.2 per cent nitrogen in the amount of trash added. The amount of carbon-dioxide production was considerably increased even when the trash was left on top of the soil as a mulch, but it was slightly below that produced when the trash was mixed with the soil. As to the nitrate-nitrogen content of the soil at the close of the experiment, a decided advantage was shown by the mulched soils over those mixed with trash. Mulched soils showed the presence of considerable nitrate nitrogen even when they were slightly below soils receiving no treatment; on the other hand, soils mixed with trash showed only traces of nitrates even in the pots receiving nitrates in addition.

A third experiment, lasting 11 days, was made, the amounts of nitrates added to the soil in flasks being varied to observe the effect on the amount of carbon dioxide produced. Then the experiment was carried on for 30 days without carbon dioxide determination and for a third period of 12 days with it. Nitrate nitrogen was determined in the air-dried soil samples.

The applications of nitrogen as nitrates were equivalent to 0.5, 1, 1.5, and 2.5 per cent of the dry weight of the trash. Only on the first day of the 11-day period was the difference in the amount of carbon dioxide evolved for the different treatments noticeable. Apparently the increase in nitrate content did not affect the decomposition of the trash. Even after the decomposition had been allowed to proceed for 41 days and another measurement had been made of the amount of carbon dioxide evolved for 12 consecutive days this failed to show a difference in favor of the nitrogen applications. At the end of the test the nitrate-nitrogen content was determined. Even soils receiving no nitrate nitrogen were found to contain varying amounts. Those receiving different amounts of nitrate nitrogen showed increased nitrate content in accordance with the amount received, but they were less than the amounts applied. Lime again seemed to be beneficial since a gain in nitrate was always observed following its use. Apparently the rate of decomposition of cane trash when it was added to a soil progressed sufficiently in two months to permit nitrification of the nitrogen present and especially so when lime was added.

To obtain further information on this point and on the rate of nitrification of the nitrogen of cane trash, an experiment was carried on in beakers. The beakers were allowed to stand for four weeks before the nitrates were determined for the first time. Nitrate nitrogen was then added, and nitrate determinations were made weekly for five weeks.

Mixing cane trash with the soil reduced its nitrate-nitrogen content for four weeks, even when the soil was limed. However, nitrate nitrogen when added in the fifth week was apparently little affected, the soils showing a very small decrease in the amount added. Soils to which the trash was added as mulch were not affected as much as were those having it mixed with them. On the other hand, soils containing a mixture of cowpea leaves and stems soon showed decomposition and the presence of nitrates, the contents surpassing those of soils not receiving any treatment. These results can not be accepted as definite because on two occasions the soils in beakers were found to be almost dry when they should have been kept at a constant moisture content.

To obtain further information on this point a second and more extensive trial was begun, in which 100 grams of soil was placed in beakers. Half the number were limed, and the rest were left unlimed. One set received no treatment, a second received 30 parts per million nitrogen as nitrate, and a third received nitrogen as ammonium sulphate. Two similar lots were prepared, the first lot receiving 1.2 grams of air-dried green and dead cane trash which was mixed with the soil; whereas, in the second the mixture was left on top as a mulch. A third lot received an equal amount of trash and potash (potassium sulphate applied at the rate of 60 pounds K_2O per acre) and phosphoric acid (superphosphate applied at the rate of 60 pounds P_2O_5 per acre) with and without the addition of lime and nitrogen as ammonium sulphate. All these were compared with two lots to which 1 gram of air-dried cowpea and velvetbean leaves and stems had been added. These tests had been carried on for nearly four weeks when they were destroyed by a storm that completely wrecked the shed in which the beakers and jars were kept. However, up to the time of the storm the nitrate content of the soil, both untreated and limed, continued to increase, while nitrogen added as ammonium sulphate was completely changed to the nitrate form. Where trash had been mixed with limed or unlimed soil no nitrates were found in the unlimed soils and only bare traces in the limed. Given the same treatment and in addition nitrates or ammonium sulphate, unlimed soils showed bare traces and limed soils from 10 to 15 parts per million. In soils receiving trash as a mulch the nitrates did not disappear even when the trash was applied alone. All soils receiving potash and phosphates, and nitrogen as ammonia, in addition to trash, showed bare traces even when limed, whereas soils with cowpea or velvetbeans showed an increase of 20 to 90 parts per million nitrogen as nitrate in the fourth week of the trial.

Another experiment was begun, but as no cowpea or velvetbean plants were available, air-dried green and dead cane trash was substituted to permit of determining any difference in the rate of decomposition. The experiment was carried on for 14 weeks, and samples were not analyzed until after the first 2 weeks.

Definite gains in nitrate-nitrogen content were made by soils receiving no treatment or only lime, the latter always showing to advantage. Soils to which cane trash but no lime was added showed only traces for 12 weeks and only in the last 2 weeks nitrates amounting to 7 to 8 parts per million, whereas soils receiving lime showed the presence of nitrates in the fifth week. Soils receiving nitrate or ammonia nitrogen showed the presence of nitrate nitrogen very early in the third week. The unlimed soils with ammonium sulphate required 5 weeks for such a showing. The soils varied somewhat, especially in the first 2 weeks, when a high nitrate content was observed. This suddenly dropped between the seventh and tenth weeks. The first was found to be due to the fact that the cane trash had not been attacked and, consequently, decomposition had not taken place. Cane trash does not easily absorb moisture, a fact which delays its decomposition. Again, after several weeks of gains in nitrate-nitrogen formation, the nitrate content dropped suddenly, after which gains in nitrate nitrogen were observed. These losses took place every time water had to be added to restore the amount lost by evaporation. After water was added the nitrate content increased. Soils receiving the trash as mulch showed nitrate nitrogen present during all stages of the experiment. However, they were also subject to a drop in nitrate content whenever water had to be added even though evaporation was considerably less than in the unmulched soils. Those receiving potash and phosphoric acid showed no improvement in the amount of nitrogen nitrified when they were compared with soils receiving trash alone. Soils to which air-dried green trash or air-dried dead trash were added showed considerable difference in rate of decomposition and appearance of nitrates. For green trash unlimed, nitrates appeared in the fifth week and increased gradually, whereas for the limed soils nitrates appeared in the third week, gained gradually, and in the end were twice as high as in the unlimed soils. Those receiving air-dried dead trash unlimed showed only traces throughout, whereas the limed soils showed small amounts beginning with the seventh week. It should be remembered that these experiments were made on air-dried samples of soil, which always show increased nitrification of the soil nitrogen.

Apparently decomposition of cane trash, whether air-dried green or dead trash, or a mixture of the two, progresses rapidly enough in two months' time to permit formation of much-needed nitrate nitrogen in such quantities as are necessary to plants. This action is greatly hastened by adding lime to the soil, and, while decomposition is not apparently hastened by adding nitrogen in its nitrate or ammonia forms, the earlier reappearance of nitrate is thereby obtained. When the trash is applied as a mulch the denitrifying action does not appear to be as vigorous as when the trash and the soil are mixed, presumably because of the contact of the small amount of trash with the soil. Such trash is kept moist and decomposes, whereas the rest is well aerated, dries rather quickly, and is not therefore acted upon; hence, denitrification is reduced. As soil moisture is reduced, soils appear to gain in nitrate content, whereas the addition of water to restore that lost by evaporation reduces

nitrates in samples receiving trash. This action, though not definitely known to occur, may be beneficial, for the reduction of the nitrates to some organic form may prevent loss by leaching.

REPORT OF THE HORTICULTURIST

By T. B. McClelland

COFFEE

Results of the station experiments with fertilizer for coffee show in increasing measure the need for fertilizers. Soil conditions must be improved if Arabian coffee is to continue to be grown on typical Porto Rican coffee plantations the original fertility of which was depleted years ago. At various farmers' meetings which were held in the coffee district, the horticulturist gave talks on the benefit to be derived from the use of fertilizers, and exhibited charts showing that production increased when fertilizers were applied to coffee trees. During the past seven years the total production of coffee on the two plats receiving complete fertilizer on the López plantation was 2,692 and 2,712 pounds of coffee (parchment free) per acre, respectively. Fertilizer was applied twice annually throughout this period, each application consisting, on a per acre basis, of 112.5 pounds of ammonium sulphate on one plat and 150 pounds of sodium nitrate on the other, and 150 pounds of superphosphate and 50 pounds of potassium sulphate on each plat. In this same period the two plats which prior to December, 1926, had received nitrogen only, produced at the rate of 1,250 and 1,930 pounds per acre, respectively, and the check plat, at the rate of 1,518 pounds per acre. At present prices of coffee and fertilizer, the value of the increase in crop in this instance was about twice as great as the production cost entailed through the use of complete fertilizer. Since results with other experiments in progress indicate the importance of potash in coffee fertilization, planters are advised to use a considerably higher proportion of potash than was employed in the test here reported.

In the South Field fertilized coffee plats, nitrogen, phosphorous, and potash are applied singly and in combination, the applications of each ranging from very light to very heavy. If all the plats receiving the same kind of fertilizer in different amounts are considered as a unit, and the resultant groups are compared with the unfertilized plats, the production of the NK and NPK groups will be found to have exceeded that of the check in each of the past 11 years. The K group surpassed the check in 10 of 11 years, while the PK group surpassed it in 8 of 11 years. These plats, all of which had received potash, stand in interesting contrast to those to which potash had not been applied. The check outyielded the P and NP groups in 10 of 11 years and the N group every year.

The question of the advisability of topping coffee trees has recently received considerable attention from growers. Here and there in the coffee section, coffee trees have been headed back to test the effect of topping on yield. A manuscript giving the results of an experiment in topping coffee trees at the station over a 12-year period was submitted for publication during the year.[1] The depressing effect on

[1] McClelland, T. B. Effect of topping on yield of coffee in Porto Rico. Porto Rico Agr. Expt. Sta. Bul. 32, 8 p., illus. 1928.

production of severe pruning or heading back was less evident in the early years of the test than later. During a 10-year period trees topped at 6 feet and maintained at this height produced only 74 per cent and those topped at 4 feet produced 58 per cent as much as the unpruned check trees.

One of the experimental coffee plantings was heavily invaded by a trunk borer belonging to the genus Xyleutes. Paradichlorobenzene, dissolved in soluble pine-tar oil (1 pound of the former to 1 quart of oil), and diluted with two parts of water, was injected into the tunnels by means of a small hand sprayer having a syringelike nozzle. The percentage of kill could not be determined, because of experimental work in progress with the trees. However, the treatment offers promise since two applications of the paradichlorobenzene were made at a 3-week interval without resultant injury to the trees. The borer has also been found attacking *Gliricidia sepium*, a coffee shade tree.

Planters are evincing a steadily increasing interest in Excelsa coffee. (Fig. 5.) Seed distribution of this variety has been on an extensive scale. The trees in the station plantings on poor, red clay soil under conditions little suited to Arabian coffee have made vigorous growth and produced good crops. Twelve-year-old trees are producing, per tree, about 3 pounds of coffee, with the parchment removed. The trees have averaged for the last five years a little more than 2 pounds per tree annually. The ability of Excelsa to thrive and produce under conditions unfavorable to Arabian coffee makes the variety very promising for planting in many localities, particularly where a less fertile soil, the presence of the leaf miner, a lack of suitable shade, or an insufficiency of the requisite labor during the picking season, constitute major problems.

PHOTOPERIODISM

Studies of the photoperiodism of various economic plants were continued, and a detailed report covering the main lines of investigation to date was submitted for publication.[2]

The 11 and 13½ hour periods of daily light exposure under which pineapples had produced their first crop were altered to 10 and 15 hours, respectively, for the second or sucker crop. For the latter, the differences in ripening season between groups receiving different exposures were more pronounced than in the first crop. The mean ripening date for the group receiving the normal light exposure was 21 days later, and for the group receiving the 15-hour daily light exposure, 58 days later than for the group receiving the 10-hour exposure. The average fruit produced under the 15-hour daily light exposure weighed 24 per cent more than that produced under the 10-hour daily light exposure, was both longer and broader, and was subtended by a greater number of slips. Only a single fruit of those produced under the normal light exposure attained the weight of the average fruit produced under the 15-hour daily light exposure. Weights taken at the termination of the test showed that the amount of plant growth was correlated to the length of daily light exposure.

[2] McCLELLAND, T. B. STUDIES OF THE PHOTOPERIODISM OF SOME ECONOMIC PLANTS. Jour. Agr. Research 37: 603–628, illus. 1928.

Such blossoming as had taken place prior to the removal of the plants showed that flowering for the third crop, as for the first and second, was retarded under the lengthened period of illumination.

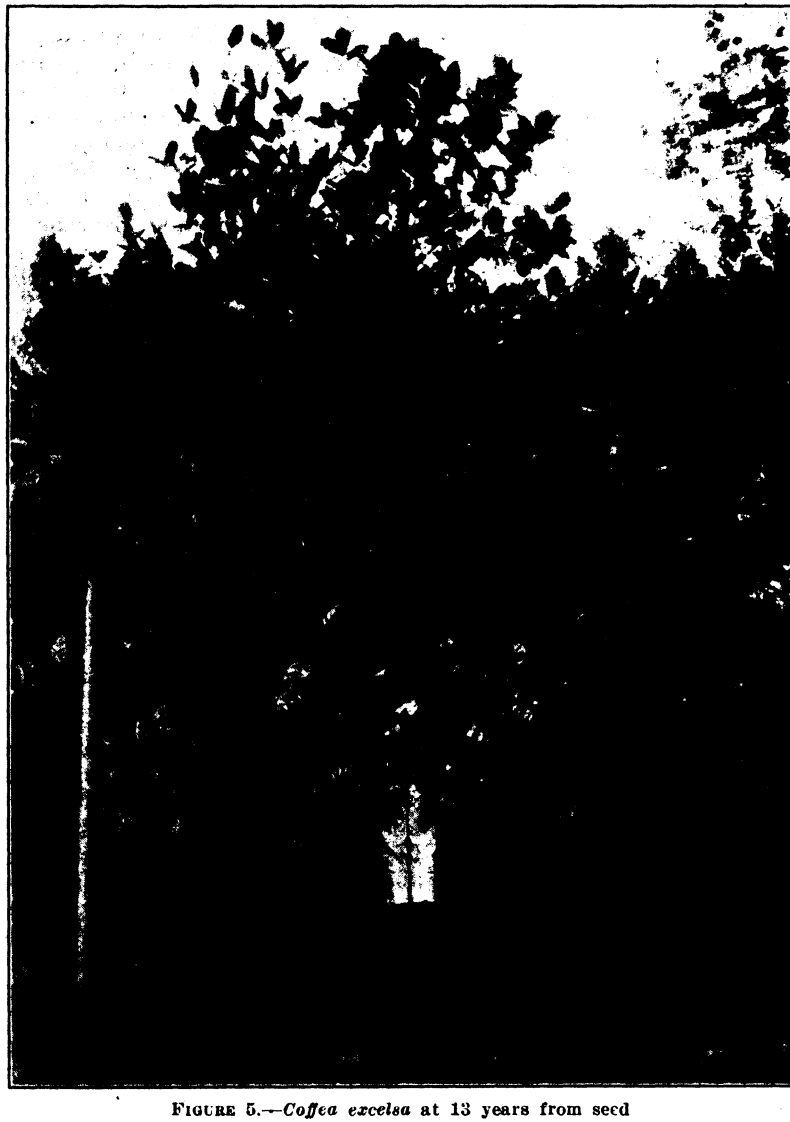

FIGURE 5.—*Coffea excelsa* at 13 years from seed

Yautias, dasheens, and Penang taros were grown under daily light exposures of 10 and 15 hours. The petiole length and the leaf diameters of the two largest leaves on each plant were measured eight weeks after planting. At that time the dasheens and taros had developed longer and broader leaves and all three had developed longer petioles under the longer exposure.

YAUTIAS, DASHEENS, AND TAROS

In planting yautias, dasheens, and taros the general practice locally is to remove the soil to a depth of 3 to 5 inches, making for each plant a hole approximately a foot in diameter which is left open. The hole gradually fills by subsequent cultivations. To test the value of this practice, the central section of each of 19 rows was holed prior to planting; whereas the sections of each side were left level. The average production per plant of corms or tubers suitable for table use was greater for the holed section in all but 2 of the 19 rows. Inequality in field conditions which was not apparent prior to planting affected the growth to a greater extent than did the planting methods tested. The tests are therefore being repeated.

A trial shipment of dasheens was made to New York in February. These tubers sold at 3½ cents a pound. A little more than 4 cents a pound was offered for tubers of similar quality in April. Considering the heavy production per acre in fertile soil—8 or 9 tons of tubers suitable for shipment and 2 or more tons of large corms suitable for local consumption—it is thought that the crop promises profitable returns to the grower. Shipments in the early fall or the late spring are advisable rather than in midwinter, when supplies from elsewhere are abundant.

The effect on production of planting Penang taro cormels of different sizes has been tested for four years. The sizes of cormels planted though varying slightly in the course of the test have been approximately 2 ounces or less for the smallest size, 3 ounces for the second, 4 to 5 ounces for the third, and 6 to 11 ounces for the largest size. Considering the four years' production as a whole, it is seen that the difference in yield has been insignificant. The highest yield has been obtained from planting cormels weighing 2 ounces or less, the second highest from cormels of 3 ounces, and the lowest yield from the cormels of largest size. The extremes differed by about 8 per cent. The annual yields individually have not held to a uniform sequence, but have varied from year to year, the production from the smallest and from the largest cormels having held first place one year and last place another. Evidently the yield of Penang taro has not been significantly affected by the size of cormel planted. As the large cormels not only are valuable as food, but are more likely to rot than are the smaller cormels, the latter should be preferred to the former for planting.

YAMS

Selections were made from the lowest and highest yielding plants of yams to test different strains for productivity. The selected plants ranged in weight of tubers from 4 ounces to 2 pounds 14 ounces for those of lowest yield, and from 4 pounds 1 ounce to 8 pounds 10 ounces for the plants of highest yield. Each selection was planted separately. Either small whole tubers were planted, or larger tubers were cut to secure uniformity in weight of seed piece within the variety. Of six varieties included in the test, five showed on the whole a higher average production by the progeny derived from the low-yielding hills. In the following planting such strains as appeared to be of promise were retained, and some new selections were made to continue the test a second season.

COCONUTS

At the Harvey coconut plantation, palms receiving 5 pounds of salt twice annually produced an average of 63 nuts per palm, whereas the unsalted palms constituting the check produced 61.9 nuts per palm for the year ending December, 1927. This was a reduction in yield over that of the preceding year of 5.5 nuts per palm in the plat receiving salt, and 11 nuts per palm in the check plat. Fertilizer applications to these plats were discontinued in January, 1926, and salt was applied for the first time in May, 1926, the new plats running crosswise of the old. At Corsica a fertilizer experiment has now been in progress for six years. In comparing the production of the first two years with that of the last two years, it is seen that the yield of the check remained stationary, whereas all of the fertilized plats show an increase in yield. This increase amounted to 13 and 23 per cent for the plats receiving incomplete fertilizer, and 29 and 91 per cent for those receiving complete fertilizer.

VIOLET TREE

Seeds of the endemic, indigenous, and now very rare violet tree (*Phlebotœnia cowellii*), were secured and planted, and the resultant seedlings are thriving. This tree, beautiful for its flowers and valuable for its very hard wood, has for a long time seemed to be in danger of becoming extinct.

REPORT OF THE PLANT BREEDER

By R. L. Davis

FIELD CORN

Selfed lines were continued from high-yielding ears from the various districts. Number 6–7–3, a particularly promising line from Morovis, produced ears that in total length per plant exceeded those of normal open-pollinated corn. As was the case in previous years, the most vigorous lines, regardless of the number of generations selfed, came from Castillear–1, a champion high-yielding parent ear which was collected at Penuelas. These lines from Penuelas are very slow in approaching uniformity. Castillear 1–5–2–4–5 after four generations of inbreeding shows considerable variation in type and color of kernel, and in number of kernel rows. In contrast to this, Vincens-Flint 2–4–1–2–5, a line which has been inbred to the same extent but was derived from another source, is nearly uniform, all the kernels being flinty and of orange color, and nine-tenths of the ears being 10-rowed.

The lines thus far isolated from the upland districts near Barranquitas and Aibonito have not, when grown at Mayaguez, shown vigor at all comparable with those from lowland districts. They do not appear to be adapted to the lower altitude. Their plant growth is large, but the ears developed are not sound. Lines that grow vigorously at Mayaguez have been isolated from the four lowland districts, Coamo, Lajas, Morovis, and Penuelas, where selections have been made. Selection No. 12–13–1 from Coamo is outstanding for its long ears, and it is very nearly uniform for a dimple dent type of kernel.

White-kernel lines have been isolated from Lajas, Morovis, Jayuya, Penuelas, Coamo, and Barranquitas. In each instance where planted next to yellow sister lines inbred the same number of generations, the white recessives have made an inferior plant growth and proved to be more susceptible to disease.

Twenty-five first-generation hybrids were produced by crossing yellow-kerneled lines selfed for two generations with C.–1–2–4–6, a white-kerneled line selfed for three generations. This white line makes a very inferior plant growth and produces small ears and small kernels. Because of its decided inferiority, the white line was thought to afford a good test for the degree of prepotency in the yellow lines, as only the most dominant yellow type could give a high yield in the F_1 combination. In a test by the hill check method in which common corn from the Yauco-Torre farms was used as the

FIGURE 6.—Selfed lines with high total ear length tend to produce high-yielding hybrids. Left, hybrid of pistillate parent averaging 21.2 centimeters in ear length. Exceeded check in yield by 59.7 per cent. Right, hybrid of pistillate parent averaging 16.5 centimeters in ear length. Yield 4.2 per cent less than check

standard, two interesting observations were noted, the similarity in performance of hybrids from sister lines originating from the same parent ear, and the greater prepotency of yellow lines that had made superior plant growth in the pure inbred condition. The hybrids from the sister lines, Barranquitas 22–11–1 and 22–11–2, are both low in prepotency, yielding less than 95 per cent of the check in shelled corn per acre. The same is true of hybrids from two sister lines of Castillear–1–o–p.–21, which yielded, respectively, 81.4 and 95.8 per cent of the check.

As an example of parallel performance for high prepotency, four sister lines from Castillear–1–o.–p.–50 all outyielded the check by 7 per cent or more. Of eight lines which were superior for plant growth, five were also superior to the check in first-generation hybrid combination. The average total ear length of the lines was a better criterion than plant growth for predicting prepotency, since the pistillate parents of eight of nine high-yielding hybrids were superior for total ear length. Figure 6 shows ears from two hybrids whose

pistillate parents were derived from the same parent ear. Ears from six representative plants are shown in each instance. The hybrid on the left exceeded the check in yield of shelled corn by 59.7 per cent, and its pistillate parent averaged 21.2 centimeters in total ear length. The hybrid on the right yielded 4.2 per cent less than the check, and its pistillate parent averaged only 15.5 centimeters in total ear length.

SWEET CORN

The growth of Mayaguez–1, a sweet corn which was developed from native field corn and distributed in 1928 for the first time, has not been wholly satisfactory in the dry districts of Porto Rico. Several vigorous inbred lines that are derived from the same source as Mayaguez–1 offer a solution to this difficulty, because in their inbred condition they grow taller and produce larger ears than Mayaguez–1. They are first-generation selfed lines from 27 Su–12 that grew fully 1½ feet taller than Mayaguez–1 in the spring of 1928. It is probable, however, that some trouble will be experienced in selecting for tender kernels. In this respect these lines are less promising. Crosses have been made between native sweet corn and the most vigorous selfed lines of field corn.

SUGARCANE

Several very promising importations were made during the year. P. O. J. 2364, supplied by the Bureau of Plant Industry of the United States Department of Agriculture, and Ba 6835, sent from Trinidad, are very desirable breeding material. The best varieties developed in both Java and Barbados have been bred from them.

P. O. J. 2878, from Java, has been propagated with the utmost rapidity and extended to all parts of Porto Rico. The Java water-sucker method was used in combination with the Mayaguez single-eye method to accelerate propagation. From three single eyes that germinated in March, 1927, 10 acres were planted in July, 1928. P. O. J. 2878 has given very good first ratoons at Mayaguez and is a prolific stooler, even exceeding P. O. J. 2725 in this last respect. P. O. J. 2878 does not have the objectionable feature of early arrowing. Ten-month-old "primavera"[3] and 14-month-old "gran cultura"[4] plantings of P. O. J. 2878 did not arrow, whereas, in adjoining plantings of corresponding age every cane of P. O. J. 2725 arrowed. In two small "primavera" plats P. O. J. 2878 outgrew P. O. J. 2725 by a substantial margin of nearly 2 feet. P. O. J. 2878 responds well to good cultural conditions and at Mayaguez produced canes of large diameter with joints averaging 7 inches long. It is very susceptible to the cane borer, a fact which may cause trouble in the dry districts where this pest is prevalent. The first analyses made on January 17 at Mayaguez indicate that P. O. J. 2878 is late in ripening. The juice of 15-month-old "gran cultura" from the original three stools propagated here had, on analysis, 14.1 per cent

[3] Spring planting of cane usually cut when 12 to 13 months old.
[4] Summer or fall planting of cane usually allowed to grow for 15 to 18 months before it is harvested.

sucrose and a purity of 84.2 per cent. This was several points lower than that of a seedling of S. C. 12/4 growing in the same plat. The juice of 10½-month-old "primavera" contained 14.27 per cent sucrose and had a purity of 83.7 per cent, whereas the juice of adjoining stools of P. O. J. 2725 showed on analysis 14.75 per cent sucrose and a purity of 85 per cent. The season during which these canes ripened was exceedingly adverse because of rain, which depressed the sucrose and caused the buds to shoot in the standing cane.

Of the second-year and third-year selections from hybrids between P. O. J. 2725 and S. C. 12/4, the more promising at present appear to be Mayaguez 28, 42, 44, 51, 3, 7, and 63, all of which are highly resistant to mosaic. Mayaguez 28 holds the record on sucrose at Mayaguez, exceeding that of all varieties analyzed in 1926 and in 1927. At Central Eureka, Central Coloso, and Mayaguez, this hybrid has made a growth equaling that of P. O. J. 2725 and B. H. 10/12. It stools even better than P. O. J. 2725, sheds its leaves freely, and produces canes of good diameter. Mayaguez 28 has two drawbacks: It arrows profusely, though not so early as P. O. J. 2725, and the buds shoot out badly toward maturity, making top seed undesirable for planting.

Mayaguez 42 appears to be the most promising of the 1927 hybrid seedlings. In January, 10½-month-old canes analyzed 17.62 per cent sucrose and a purity of 89.3 per cent, equaling tests on P. O. J. 2725 of the same age. Mayaguez 42 has outgrown P. O. J. 2725 in "primavera" planting, and produces canes of good girth, with extra long joints similar to those of P. O. J. 2878. It germinates well, has not arrowed at Mayaguez, and does not have hairs on the leaf sheaths.

Of all the hybrids, Mayaguez 44 most closely resembles P. O. J. 2725. It is, however, sweeter than the mother variety, and is probably much later in arrowing. It has long yellowish-green joints and broad light-green leaves that are shed very freely.

Mayaguez 51 is practically the same as P. O. J. 2725 in time of arrowing. Its growth is erect, and it sheds its leaves freely and resists wet land. It grows very rapidly and has in preliminary trials exceeded the height of P. O. J. 2725 in adjoining rows by several feet. Mayaguez 51 is outstanding for its vigorous ratoons. The canes are very long jointed, green to yellowish-green, and of a satisfactory girth, somewhat less than that of S. C. 12/4. Its juice has a sucrose content about equal to that of P. O. J. 2725.

Mayaguez 3 has for the second year outgrown B. H. 10/12 at Central Pagán, Anasco, where cooperative tests with the South Porto Rico Sugar Co. have been carried on. It is outstanding for its erect growth and tough canes of medium girth which are free from borer attack. Mayaguez 3 was germinated at the Fajardo Central experiment station and sent to the Mayaguez station while still in the germination flat in January, 1926. It is of interest to note that this seedling was at 1 month several inches taller than were any of the others in the same germination flat. Additional tests on its sucrose are needed. The first-year analysis was lower than that of P. O. J. 2725.

Mayaguez 7, which gave a low sucrose as a first-year seedling, has had promising analyses in the "gran cultura" wet-land experiment

at Mayaguez. In two plats it had an analysis on January 17 of 17.2 per cent sucrose and 17.61 per cent sucrose, respectively, whereas in P. O. J. 2725 the sucrose averaged 15.82 per cent. The purity of the juice of both varieties was about 88 per cent. Mayaguez 7 has not arrowed for three seasons at Mayaguez. It makes a rapid early growth and resists drought well. Like most of the other hybrids, it has long joints. The canes are somewhat smaller in girth than those of P. O. J. 2725 and not so erect as those of Mayaguez 3.

Of all these hybrids, Mayaguez 63 has the toughest foliage and the healthiest stools. It is a thick green cane with long joints and round buds which are well confined to the growth ring. It has withstood drought and adverse wet-land conditions well during the past two years. In young "primavera" it analyzed somewhat better than both P. O. J. 2725 and P. O. J. 2878. On January 17 "gran cultura" plantings in a very poorly drained field yielded 2 per cent less sucrose than did P. O. J. 2725. Like H. 109, B. H. 10/12, and other commercial varieties, the canes become increasingly large toward the top. Mayaguez 63, when planted next to P. O. J. 2725, made a growth at 16 months that was not inferior to that of the latter. No signs of arrowing have been observed.

The new seedlings propagated include over 1,000 selfed seedlings of B. H. 10/12, 400 crosses between B. H. 10/12 and D. 433, 50 selfed seedlings from E. K. 28, and 4 crosses between P. O. J. 2725 and Ba. 11569. In addition, selfed seedlings from Ba. 11569, D. 1135, and S. C. 12/4 were bred. The new crosses showed no promise and were discarded. Of the selfed seedlings, those of E. K. 28, Ba. 11569, and B. H. 10/12 made the best growth. Several of the B. H. 10/12 seedlings have equaled the growth of the best seedlings of E. K. 28 and are, in addition, decidedly healthier.

The principal effort in seedling propagation work for the year was centered on the problem of variable viability of sugarcane seed from arrows of the same variety. Collections of 50 arrows of S. C. 12/4 per district were made near Toa Baja, Fajardo, Humacao, Yabucoa, Manati, Arroyo, Guayama, and Ponce. The lowest germinations secured were 7 seedlings per arrow from Central Mercedita, Ponce, with no December rainfall and 3.3 seedlings per arrow from Central Aguirre near Guayama with a December rainfall of 0.06 inches. The best germinations were 134 seedlings per arrow from Yabucoa with a December rainfall of 2.19 inches, and 135 seedlings per arrow from Manati with a December rainfall of 4.78 inches. Satisfactory germinations were secured from all the other districts excepting Arroyo, where the December rainfall was very light. These data indicate that viable seed may be secured in Mayaguez and other districts that are dry during the propagation season, provided that irrigation water is applied during the periods of blossoming and maturation from November 10 to December 20. Watering the arrows gently with a fine spray from 9 a. m. to 3 p. m. during the pollination and early maturation periods reduced the germination by half. This indicates that irrigation water alone is sufficient under the natural humidity prevailing at Mayaguez during the critical period.

REPORT OF THE AGRICULTURIST

By H. C. HENRICKSEN

PINEAPPLE INVESTIGATIONS

The pineapple investigations were continued. Several new problems were attacked, and those of immediate practical importance, relating to maturity and the shipping of the fruit, were solved. The results were published in mimeographed numbers of Agricultural Notes issued by the station in order that local planters might derive immediate benefit from the findings.

Extensive cooperative field experiments were started in 1927 with the object of testing a number of methods by which the time of fruiting might be controlled.

In experiments in plant selection which have been under way for several years, the results show that such characteristics as size and vigor of plant, and size and usually the shape of fruit are transmitted from generation to generation. This was explained to planters at field meetings, and as a result several have been practicing plant selection for the past few years.

One phase of selection of very great importance to the pineapple industry in Porto Rico is the elimination of the barren type of plant locally known as "Riñon" or "Macho." This type was first noticed about 12 years ago. Since then experimental results show that 100 per cent of the plants transmit a characteristic vigorous growth with a production of very small, usually misshapen fruits which are edible but commercially valueless. This problem was very serious until the planters were made aware of it, for the plants being vegetative, produced a large number of vigorous slips which were eagerly selected for further planting. As a result, some of the plantations were producing 25 per cent or more of worthless plants before the growers became aware of the fact.

Another seemingly promising phase of selection has so far been deferred because of lack of assistance. It is generally known that some fruit is sweeter and of much better quality than other fruit. Difference in sweetness has been thought to be due partly to environment and partly to difference in maturity of fruit. That this is not entirely correct was well demonstrated in these investigations when occasional fruits were found containing nearly 2 per cent more total solids than did average fruit of equal maturity. This would seem to indicate that quality is a very promising characteristic for use in selective breeding work.

OUTWARD INDICATIONS OF FRUIT MATURITY

The outward indications of fruit maturity are very difficult to recognize. The disappearance of chlorophyll from the rind while a sure indication of maturity of fruit is of minor practical value because most of the fruit is picked before it reaches this stage. Although plant-ripened fruit is most desirable for consumption it is not so suitable for long-distance shipment as is fruit that is less mature. On the other hand, maturity must be well advanced before the fruit is picked, or the quality will be very poor. Two stages of maturity of the Red Spanish variety are readily discernible regard-

less of local conditions. One concerns the appearance of the bract or leaflet at the base of each eye. So long as the bract remains unwilted, the fruit has not matured sufficiently to have attained a high degree of palatability. The other stage concerns the color of the basal eyes. When they show a slight yellowing the fruit is of shipping maturity, but is too mature for long-distance shipment except under refrigeration.

Between the two extreme stages of maturity are several indications which vary with soil, fertilizer, moisture, and temperature. They are different, therefore, on different plantations and can be recognized only by those who are familiar with local conditions.

STAGES OF MATURITY

The stages of maturity are discernible in the texture and flavor of the flesh and in the color, taste, viscosity, and total solids content of the juice. The flesh of the immature fruit is firm and brittle and practically without pineapple flavor. As the flesh becomes increasingly tender toward maturity it develops the typical pineapple flavor.

The juice of the immature fruit is milky white in color, insipid in taste, very viscous, and has a total solids content of 9 per cent or less. As maturity progresses the color changes to yellow, the taste mellows, the viscousness greatly diminishes, and the solids content increases. The latter is usually 14 to 15 per cent in the juice of the plant-ripened fruit, and in exceptional cases it may reach 16 to 17 per cent, the basal portion containing 2 to 4 per cent more than the apex. These changes take place only in unpicked fruit. After the fruit is severed from the plant, sugar formation stops. This was definitely proved in these investigations by the removal of plugs from the fruit at several intervals and the testing of the juice in an Abbé refractometer. The plugs were removed under aseptic conditions, and the resultant cavities were filled with melted paraffin to prohibit infection. This, it was found, did not interfere with the maturity changes in the fruit.

The acidity was measured by titration and found to vary from less than 0.4 per cent in the immature fruit to upward of 0.9 per cent and occasionally more in the mature fruit. The variations were not consistent enough, however, to permit using acidity as a reliable measure of maturity.

FRUIT DECAY

One of the most serious causes of loss to the pineapple grower is decay in transit. Decay in the pineapple is brought about by the same agents producing it in other kinds of fruit, but the effect is aggravated by the very perishable nature of the mature pineapple. For this reason most of the growers are inclined to ship immature fruit. The results of investigations at the station show that plant-ripened fruit, when it is properly handled, can be safely shipped at a temperature of 35° to 40° F.

The so-called black rot of pineapples is difficult to prevent. It is usually caused by a fungus entering the stem end of the fruit after it is cut from the plant, but an overabundance of water in the fruit is always a contributory cause. Black rot is not very prevalent except

in rainy weather. It can be largely eliminated by thoroughly drying the stem scar. Sun drying is preferable, but artificial drying must be employed in cloudy weather. Several methods of artificial drying have been perfected, employing a blast of air with or without heat. One of the growers has constructed a series of frames 6 to 7 feet high, under which he sets the fruit on the ground with the stem end exposed to the sun. A covering is drawn over each frame when rain commences and is removed when it ceases.

CITRUS INVESTIGATIONS

It became necessary during the year to devote considerable time to citrus problems. Coloring and washing of the fruit, together with some other packing-house problems were investigated. A preliminary report on the results obtained was published in mimeographed form in Agricultural Notes No. 40, issued by the station.

IDENTIFICATION OF BUDDING STOCK

A survey of the citrus groves was started. One of the first difficulties encountered in the work was the determination of the stock upon which the trees are budded, the sprouts which emanate from below the bud union and are seldom present being the only sure indication available. This difficulty was overcome by the finding of a chemical method making it possible to differentiate between the stocks that have been planted in Porto Rico. These are rough lemon, sour orange, cultivated grapefruit, and occasionally the so-called native grapefruit.

The method is based upon the depth of color produced by ferric chloride when it is added to an aqueous solution of root tissue. A method, simple enough for planters to use, was described in mimeographed form in Agricultural Notes No. 43, published by the station.

In the laboratory the following method was satisfactorily used: A piece of root was washed and dried, and the bark was scraped from it. A 1-gram sample was macerated in a mortar with a few cubic centimeters of water, after which about 20 cubic centimeters of water was added. One cubic centimeter of a 5 per cent ferric chloride solution was next added and the whole stirred well. A small portion of aluminum cream was added and the mixture filtered on a small Buchner filter. The solution of the volume of the filtrate should be 50 cubic centimeters or greater, depending upon its color. The depth of the color was determined in a colorimeter in comparison with a standard solution of naringin to which ferric chloride had been added. Rough lemon showed practically no color; native grapefruit had a color equaling 4 to 6 milligrams naringin in a 50 cubic centimeter solution; cultivated grapefruit had a variable color, but usually it was equal to more than 6 milligrams and less than 10 milligrams naringin; sour orange had a very variable color, but it nearly always was equal to more than 10 milligrams naringin. This showed that rough lemon and sour orange, the two stocks commonly found in Porto Rico to-day, can readily be distinguished from each other. The native grapefruit is readily distinguished from the two former, but it can not always be so readily distinguished from some varieties

of the cultivated grapefruit. The sweet orange has seldom, if ever, been used for stock here. It will present difficulties whenever it is found because the various varieties produce a depth of color which shades into those of the different strains of the sour orange.

POT AND LYSIMETER EXPERIMENTS

Five series of sand cultures, each made up of six 10-quart containers planted with grapefruit seedlings, were under observation for five months to determine the optimum salt concentrations and changes in pH taking place as the result of applying different nutrient solutions to them. The results were practically negative because of poor plant development, in this respect paralleling the results obtained by Breazeale.[5]

Twenty-four half barrels were filled with a uniform grade of sandy clay soil which was practically devoid of organic matter and available plant nutrients. Each container was planted with six citrus seedlings which were about 3 inches tall, and various mixtures of inorganic fertilizer salts were applied to the soil. The experiments were continued for eight months, during which time the soil was tested for nitrogen and pH and the plants were measured. No definite results were obtained from the plant measurements as differences between individual plants in any one series were greater than those between plants in different series.

The pH of the soil was 6.3 at the beginning of the experiment and dropped to 5.3 in less than three months in the series receiving ammonium sulphate and potassium sulphate. In the next series, which received calcium phosphate in addition to these two substances, the pH remained practically stationary. In the series receiving urea and potassium phosphate, the pH remained practically stationary. In another series, in which sodium nitrate was substituted for urea, the pH increased slightly. These results indicate that the changes in pH were caused by such ions of the various salts as were not taken up by the plants.

In one series, which received sulphur at the rate of 1 ton per acre in addition to complete fertilizer, a pH of 3.8 was produced within two months. Some of the plants were killed outright; the rest made very little growth. Replantings were made from time to time, but growth was practically nil as the pH remained around 4. This indicates that the critical soil pH for citrus trees lies between 4 and 5.

In another series, which received air-slaked lime at the rate of 1 ton per acre, the pH was barely raised beyond 7, and it did not affect plant development.

The nitrogen determinations were made for the purpose of ascertaining to what degree nitrogen may be depleted before plant growth ceases. The results were not conclusive. On some plants new leaves were formed when the nitrate content of the soil was only 2 parts per million and the ammonia content 4 parts per million. This, however, is no indication of what the minimum content may be in commercial plantations.

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[5] BREAZEALE, J. F. VITAMIN-LIKE SUBSTANCES IN PLANT NUTRITION. Ariz. Agr. Expt. Sta. Tech. Bul. 16; p. [401]–417, illus. 1927.

After eight months some of the plants from each series were ashed and analyzed for calcium, potassium, and phosphorus. The results did not show differences that could be attributed to the fertilizers applied, but consistent differences in the ash content were apparent between the species, grapefruit and lemon containing on an average 1.5 per cent more of these substances than the sour orange.

Another result worth recording is the difference in ash content of the leaves and the stem, the former containing more than twice as much as the latter regardless of the species or the fertilizer applied.

In a third experiment, which is being carried on along the same line as the former, 50 citrus trees, each in an iron drum of 30-gallon capacity containing the same grade of soil as that used in the half barrels, are under test. The drums are so placed as to permit collection of the drainage water and are provided with practically rainproof covers when necessary. This experiment is to be continued for several years, until the trees become pot-bound, in the hope of ultimately obtaining data on optimum soil moisture, plant nutrients and pH for citrus, and the differences, if any, in these factors in relation to lemon, grapefruit, and sour orange.

FRUIT GROWERS' MEETINGS

The agriculturist acted as secretary of the fruit growers' meetings and attended the get-together luncheons which were given monthly in San Juan. Mimeographed records of these meetings, which have been sent out during the past three years, have been greatly appreciated by the fruit growers.

REPORT OF THE PLANT PATHOLOGIST

By C. M. TUCKER

AVOCADO ROOT DISEASE

Investigations on a root disease of avocados were continued. During the year trees in a commercial planting of Mexican and Guatemalan varieties which had been grafted on West Indian stocks at Villalba were found to be dying. The earliest symptoms of disease were a cessation of growth and the appearance of a yellowish, unhealthy color of foliage, which was followed by gradual defoliation and death.

Trees of all ages from young seedlings to large trees 6 to 8 years old bearing full crops of fruit were attacked. The infected seedlings were in a nursery which had been established in a section of the grove whence dead trees had been removed. The seedlings were in rows, and circular areas of dead or dying seedlings were to be found at places where infected trees had grown. The size of the infected areas corresponded rather closely to the root spread of the removed trees.

Cultures were made from roots from six infected trees, and five of them yielded a Phytophthora which was identical morphologically with the fungus that was repeatedly isolated from trees showing the same disease symptoms at the station. (Fig. 7.) The Phytophthora closely resembles *P. cinnamomi*. The species is well differentiated by the production of grapelike clusters of chlamydospores and the ab-

sence, in ordinary cultures, of zoosporangia and oospores. There is some evidence, however, that the avocado strain differs from cinnamon strains in pathogenicity.

Inoculation experiments on West Indian seedlings grown in autoclaved soil demonstrated the ability of the fungus to attack and kill the roots. In most instances the effect of the parasite is rather slow. Of six plants that were inoculated January 30, 1928, four were dead

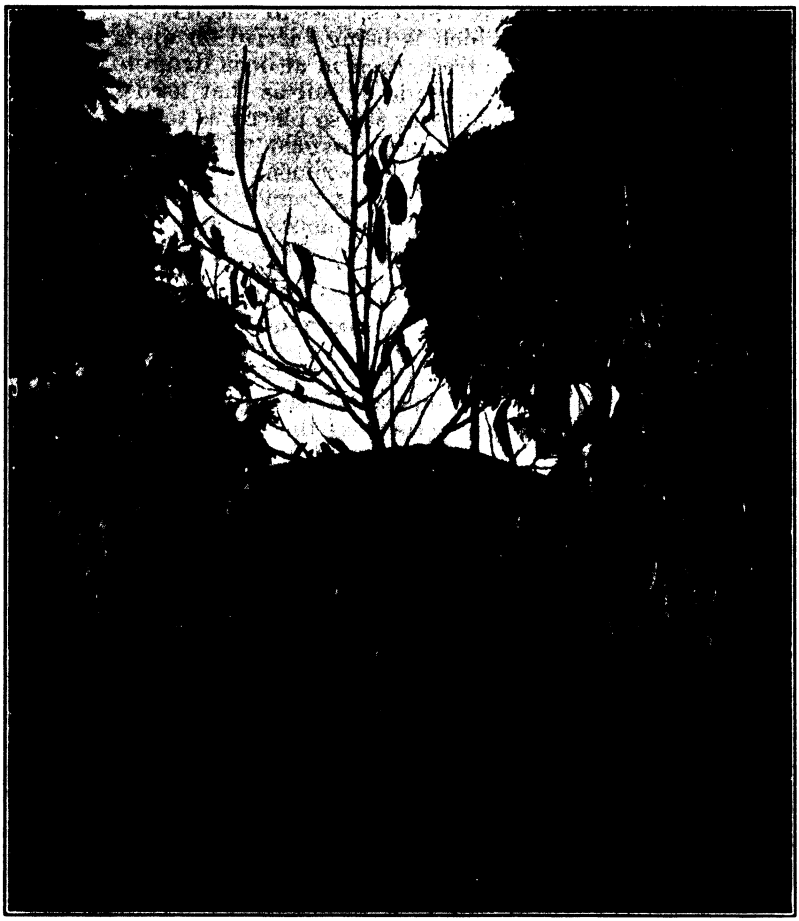

FIGURE 7.—Young Dickinson avocado grafted on West Indian stock dying from root disease. Located on a hillside in heavy clay soil

on July 7, 1928. The two living plants had made no growth. The check plants were healthy and growing vigorously. (Fig. 8.)

Examination of the roots of healthy and diseased plants revealed that practically all the roots of the inoculated plants had rotted. In Figure 9 the roots of an infected plant (on the left) were taken from a badly wilted plant which was barely kept alive by the proliferation of small, weak roots near the crown. Such roots seem to become infected rather early and seldom become sufficiently widespread to cause renewed growth.

The disease occurs frequently in heavy soils and in poorly drained locations. At the station young trees on fairly steep slopes have succumbed. The soil is a heavy clay. At Villalba the disease first appeared on a rather poorly drained plateau at the base of a precipitous slope from which the plateau received the run-off. The surface 15 inches of soil was a gravelly, friable loam. The subsoil was a yellow, tight clay. At this place many of the trees attained

FIGURE 8.—Inoculation experiments with avocado. Left, two check plants; right, inoculated January 20, 1928, and photographed July 7, 1928. The plants were of equal height at the beginning of the experiment

large size before they were killed. This fact was probably due to the favorable conditions encountered by the roots in the surface soil during the early life of the tree and to their infection upon reaching the impermeable subsoil.

It is apparent from the observations made that commercial plantings of avocados are most likely to succeed in places having a deep, permeable soil and good surface drainage. The degree of surface

and subsurface drainage necessary naturally varies considerably with the rainfall.

Observations indicate that infection and rotting of roots occur mostly during the rainy season. Attacked trees may, however, remain healthy in appearance until a few weeks after the beginning of the dry season when the reduced root system, under scanty moisture conditions, is no longer able to supply the necessary water to the plant.

CITRUS SCAB

During the year a majority of the first generation Duncan-Triumph grapefruit hybrids came into bearing. The first-generation trees,

FIGURE 9.—Root disease of avocado. Left, root system of the plant on the left in Figure 8. Right, root system of the plant on the right in Figure 8. The only functioning roots are the few small ones arising near the crown

bred in an effort to obtain a desirable grapefruit having the scab-resistant character of the Triumph variety, proved to be as susceptible to scab as the susceptible parent Duncan.

Seeds from fruits of the hybrids were planted in boxes in January and the resultant seedlings transplanted to the nursery in April. About 3 acres of plants set 6 inches apart in rows 3 feet apart were obtained. Some of these second-generation seedlings were lost during the unusually heavy rains of the summer, but a large number of them are in very good condition. Scab infection has already appeared on the leaves and young stems, and the elimination of susceptible individuals will be begun in the spring of 1929 during the period when natural infection is most prevalent.

PHYTOPHTHORA INVESTIGATIONS

The collection of Phytophthora species and strains maintained under culture was considerably increased by acquisitions from other investigators, and many requests for cultures were granted. Investigations into the pathogenicity and morphology of the strains were continued.

Of special interest are two diseases caused by fungi of this genus found during the year for the first time in Porto Rico. In April, following a period of very heavy rains, an outbreak of a severe epidemic among pepper plants was observed. The plants were 3 to 12 inches tall. The fungus invaded the tender stem tips and the leaves. Attacked stems turned black, shrank, and collapsed. Spots one-half inch in diameter to larger ones involving the entire area were found on the leaves. The spots were brownish green in color and became dry and parchmentlike. Infected leaves fell prematurely from the plants. The mortality among the plants was about 60 per cent. Infected plants seldom recovered. On the blackened stems zoosporangia were produced in great profusion presenting a whitish, mealy appearance. From these stems the causal Phytophthora was isolated and the disease reproduced by inoculations. Wound inoculations of pepper stems near the soil level resulted in the death of the plants in three days.

Many of the fallen grapefruits which had lain on wet soil for several days were damaged by a rot which began on the side in contact with the soil. The fruit remained fairly firm in texture, and the brown-invaded areas of skin became somewhat leathery. Fruits showing initial stages of infection were entirely invaded and covered with a white cottony growth of mycelium after three days in a moist chamber. The mycelium produced a few chlamydospores, but zoosporangia were rarely seen. In culture the Phytophthora differs morphologically from *P. citrophthora*, the common brown-rot fungus of California. In Australia a brown rot of citrus is caused by *P. hibernalis*, which differs both morphologically and physiologically from the Porto Rico isolation.

Infections of fruits on the trees have not been observed, and the soil is apparently the usual habitat of the fungus. Occasional cases of brown rot recorded on Porto Rican fruit in the New York market are believed to have been the result of shipping fallen fruit or of allowing the fruit to come in contact with moist soil.

POKKAH BOENG DISEASE OF SUGARCANE

The sugarcane disease known as pokkah boeng,[6] which is common in Java, and in Louisiana, Cuba, and Hawaii, especially on recently introduced Java seedlings, was observed at the station in January, 1927, on a hybrid produced by crossing P. O. J. 2725 and S. C. 12/4.

The symptoms of the disease in Porto Rico agree in certain respects with descriptions of those occurring in Java and Cuba. Chlorotic spots on the leaves, usually near the base, are said to be the earliest symptom. These spots are apparent on unrolling leaves and are

[6] Javanese words signifying "damaged top."

not developed on expanded leaves. In some instances wrinkling of the chlorotic areas occurs; in others, there is no distortion, and in yet other instances conspicuous wrinkling occurs on otherwise apparently normal green tissue. In some instances a chlorotic wrinkled area may appear near the base of a leaf and on the succeeding leaf a wrinkling of similar pattern may appear about half way between the base and the tip, whereas, in the second succeeding leaf the wrinkling may appear near the tip. The position of the wrinkled areas indicates that the wrinkling occurred while those areas were in close contact in the leaf spindle.

The chlorotic areas usually show red or reddish-brown spots or streaks soon after the leaf unrolls. In Java and Cuba a further stage of the disease is said to be a top rot. In Java the infection is reported to extend into the stalk below the growing point, where it causes cavities and strands of reddish tissues which are crossed by dark bands, producing a ladderlike appearance. These latter symptoms have not been observed in Porto Rico.

The varieties on which the chlorotic spots most frequently appear are the Java canes produced by crosses between P. O. J. 2364 and E. K. 28, and on crosses between the progeny of this cross and other varieties. Among the progeny of the P. O. J. 2364 and E. K. 28 cross the varieties P. O. J. 2725, P. O. J. 2714, P. O. J. 2878, and others are susceptible. Of these, the P. O. J. 2878 seems to be the most frequently affected. Crosses between P. O. J. 2725 and S. C. 12/4 are very frequently affected. The stool on which the disease was first noticed, carried in the station records as J. S. C. 363, showed the chlorotic spots more conspicuously than did either P. O. J. 2725 or P. O. J. 2878. A number of other seedlings produced by the station and by the Fajardo Sugar Co. produce leaves similarly affected. Other varieties occasionally produce leaves with slightly chlorotic spots, but no distortion has been observed.

The effect of the disease on the cane is problematical. At the station a planting of P. O. J. 2878 made in March, 1927, began to show chlorotic spots in June of the same year. The cane continued to make apparently normal growth to maturity. Ratoons from these stools showed no abnormalities until they reached a height of 4 to 5 feet. They, too, then began to produce occasional leaves showing the typical chlorotic area near the base. These ratoons are now mature. No cases of top rot have occurred, and, so far as it can be determined, the cane has not been injured.

The first planting of P. O. J. 2878 for commercial purposes was made by the Coloso Sugar Co. near Aguadilla. The cane was being propagated continuously, and the planting contained stools of various heights ranging from a few inches to 9 or 10 feet. Each stool was examined carefully for evidences of infection. The planting contained 685 stools, of which 73 were found to have a chlorotic area at the base of one or more leaves. In 12 instances reddish brown discolorations were observed in the chlorotic areas, usually being accompanied by splitting of the tissue.

In the planting 33 cases of top rot (dead growing point) were found. Of these, 25 occurred among very young canes and were caused by insect pests, usually the mole cricket and in a few instances the moth borer. The insects had fed upon the young leaves in the

leaf spindle or the growing point. Of the 8 cases found among older canes, 5 were caused by the moth borer and 3 were due to some undetermined cause. Of the latter, two occurred on stalks which showed no evidence of pokkah boeng. The third occurred on a stalk having three leaves with chlorotic markings.

Very young stools less than 2 feet tall showed no disease. Symptoms were observed on 6 stools 2 to 3 feet high, 5 stools 4 to 5 feet high, 3 stools 6 to 7 feet high, and 59 stools 8 to 10 feet high.

Among the stools 2 to 3 feet tall only traces of chlorotic areas could be seen. The distribution of the entire population into the different height classes was not made, but the class 2 to 3 feet tall appeared to be the largest.

The above observations were made following a season of abnormally wet weather which would appear to favor infections. Of interest in this connection was the appearance of a red stripe disease, probably bacterial in nature, on the emerging leaves on four stalks. The latter disease is probably identical with one previously observed on B. H. 10/12.

Small plantings of P. O. J. 2878 have been made in many sections. Visits were made by the plant pathologist to some of the oldest of these at Santa Rita, Fortuna, Central Mercedita, Aguirre, Caguas, Humacao, and Fajardo. At each place cane 8 feet or more in height was growing. In every instance some chlorotic leaf bases could be found. No cases of top rot were seen, and no evidence could be obtained that any had ever occurred. The plantings of this variety were being watched with much interest and it is unlikely therefore that a dead top would have escaped notice.

Isolations from the reddish discolored tissue from chlorotic spots yielded two Fusarium strains. Fusaria were present in about 90 per cent of the approximately 200 platings examined. The two strains were obtained in almost equal numbers.

Since the chlorotic areas are reported to be the earliest symptom of invasion, it was considered probable that the causal organism might be obtained from young chlorotic spots with most certainty. Accordingly, more than 200 platings of young spots showing no reddish or brownish discolorations were made. The tissues plated were obtained from the varieties P. O. J. 2878, F. C. 933, F. C. 915, F. C. 937, B417, and M. P. R. 14. The plantings from which the leaves were obtained were located at Mayaguez, Santa Rita, Fajardo, Central Mercedita, Humacao, Caguas, and Fortuna. In no instance was a Fusarium obtained.

At the same time nearly 50 pieces of tissue of P. O. J. 2878 showing discoloration were plated, and Fusaria were obtained from 93 per cent.

Inoculation experiments have shown that the Fusaria are very weak parasites capable of causing only insignificant lesions even when placed on the wounded central roll of young leaves and kept constantly wet. No traces of chlorotic spots resulted. Inoculations of cuttings by injections of suspensions of the fungi failed to produce the disease in the daughter plants, or to affect the germination of the cuttings. Efforts to transmit the disease by planting cuttings from diseased stalks were not successful. The investigations are being continued.

REPORT OF THE PARASITOLOGIST

By H. L. VAN VOLKENBERG

GENERAL SURVEY

Several species of internal parasites of horses were collected during the year. Post-mortem examination of one horse and two mules from the same locality revealed the presence of nose bot-fly larvae in the stomach, tapeworms, pinworms, and several species of Strongylinae in the intestines, a filarial worm in the peritoneal cavity, an Onchocerca in the cervical ligament, and lungworms in one of the mules. A worm aneurism was found in the anterior mesenteric artery of the horse.

Demodectic mange mites have been collected several times from swine. Observations made at the local abattoir indicate that this mange is not uncommon.

Cysticercus cellulosæ was again observed. Of a total of 6,323 hogs which were slaughtered during 1928, 8 carcasses were condemned at the local abattoir on account of this parasite.

In May, six native pigs about 1 month of age were purchased at the local market. Within two weeks five of them died from an infection with *Balantidium coli*. Ulcers were extensively found, especially in the caecum of the animals. The sixth pig, although it was kept in a small pen with two of the others, did not become sick.

Manson's eye worm has been found frequently this year in autopsies made on poultry. The air-sac mite has also been found.

Screw-worm flies are a common pest. Any open wound in animals, unless treated at once, is likely to become infected with the larvae or maggots of the fly.

The leech is an intermittent parasite which does not receive sufficient attention. Most of the swampy lands used for pastures are infested with leeches. They attack any accessible portion of the body of cattle drinking or standing in the water. The permanent swamps of Porto Rico serve as reservoirs of infection for several serious parasites. They provide breeding places for mosquitoes attacking both animals and man and for the propagation of snails, including a species which transmits blood flukes to man and possibly to animals, and another which transmits the liver fluke to animals and occasionally to man.

LIVER FLUKES

The snail (*Lymnæa cubensis*) is the intermediate host of the liver fluke (*Fasciola hepatica*) in Porto Rico. This has been demonstrated both by infecting this snail with the miracidia developed from the ova of the fluke and by infecting calves and rabbits with the resulting encysted cercariae. This snail is found in mud in swampy land and along shallow sluggish streams and drainage ditches. The specific identity of this snail was determined by Dr. Paul Bartsch, of the United States National Museum.

A small percentage of these snails was found to be infected with a stubby fork-tailed cercariae. *L. cubensis* and the snail *Planorbis guadeloupensis*, which transmits the blood fluke, *Schistosoma mansoni*, in man, were found to have similar habitats, although the latter

snail apparently has a wider distribution. Any campaign for snail eradication should include both species.

Examination showed that a very high percentage of *P. guadeloupensis* was infected with cercariae of five different kinds. One of these which encysts on fish was by far the most common. Snails infected with the intermediate stage of the blood fluke were collected several times at Cuatro Hermanos, at Mayaguez, in the vicinity of Anasco, and at Cartagena lagoon.

Experiments in the treatment for liver flukes were carried on. Heavily infested oxen which are brought to the local abattoir for meat purposes are being used in the studies. The animals weigh approximately 800 pounds each. The effect of the drug used is determined by an examination of the liver 3 to 10 days after the animals receive the last treatment. Large single doses of carbon tetrachloride (50 and 100 c. c.), tetrachlorethylene (50 c. c.), and carbon disulphide (20 c. c.) apparently had no effect whatever in destroying the flukes. This seems to be unusual, because single doses of 1 cubic centimeter of carbon tetrachloride are said to destroy all mature flukes in both sheep and goats. However, daily small doses have shown some efficiency. In one case 10 cubic centimeters daily over a period of 20 days destroyed all the flukes in a heavily infested animal. This work is being carried on as rapidly as suitable animals become available.

SWINE KIDNEY WORM

Life history.—Under laboratory conditions the ova of *Stephanurus dentatus* hatch in 36 hours upward. The larvae reach the infective stage in four or more days after moulting twice. The infective larvae are ensheathed. Infection of the pig is easily accomplished by way of the mouth. The larvae pass to the portal vein and hepatic artery and their branches in the liver, where an intermediate stage of development is undergone. After these worms reach a length of approximately 15 millimeters they migrate from these vessels through the liver, usually to the fat surrounding the kidneys, and some eventually develop to maturity in cysts along the ureters and discharge ova through fistulous tracts into these tubes. The length of time between infection and appearance of the ova in the urine is about six months.

The developing worms in the portal vein and hepatic artery cause the formation of thrombi and diffuse aneurisms. In cases in which several or many larvae lodge and develop simultaneously in one area a sacculated aneurism forms. Often the migrating worms rest for a time close to or underneath the capsule of the liver, thus causing a pocket of pus to form. The abscesses and irritation caused by the worm later result in the formation of hard nodules; and often in heavily infested animals extensive areas of the liver are replaced by connective tissue. The migrating worms which enter the kidney probably through the hilus occasionally wander on through the cortex, producing hemorrhagic tracts which are later replaced by characteristic scar tissue. Some develop to maturity in the medulla and discharge ova into the pelvis of the kidney.

Often various-sized worms are found in small, round, thick-walled nodules in the parenchyma of the liver and in thrombi in the posterior vena cava where this vessel is embedded in the liver. Apparently these forms, differing from the actively migrating worms, remain in

these locations for some time and probably undergo some development, although a portion of those in the liver eventually degenerate. Evidently the worms in the vena cava are finally carried forward to the lungs. It is also possible that some of them work their way back through this vein to the kidneys, the spinal canal, and other tissues drained by the vein.

The pus formation associated with this parasite may be a factor in assisting its penetration through the capsule of the liver and later producing the fistulous tracts opening into the ureters. The possibility that the worms which are connected with the ureters by fistulous tracts reached this location by entering the kidneys, passing into the ureters, and penetrating the walls probably by way of the glands in these tubes, could not be demonstrated. Only the mature worm has been found in and projecting into the ureters. The movement of the mature worm through the fistulous tracts into the ureters was probably brought about by a lowering of the body temperature or other post-mortem changes.

In Porto Rico infection occurs during the entire year, but is heaviest during the summer months or wet season. At the local abattoir nearly all the livers which are condemned are rejected because of pathological lesions resulting from the development of the parasite. Records furnished by local sanitation officials for the last two years show that the number of livers condemned rarely falls below 10 per cent per month, but that during December and January, the months in which the migrating worms are most numerous, one-fourth to one-fifth of the livers are condemned. It is interesting to note that the beginning of the rainy season is followed five and six months later by an increase in the number and percentage of livers condemned at the local abattoir.

During 1928, 892 livers in a total of 6,323 were condemned. These figures do not represent the total number of animals or percentage infected with this parasite for several reasons. Often the liver lesions are localized in one lobe or small area; this part is rejected, and the liver is not included in the count.

HOOKWORM OF SWINE

Further studies were made of the swine hookworm (*Necator suillus*). Locally the intestines of swine are used for sausage casings and are comparatively high in price. For this reason and because of the apparent low percentage of infection, a piece of the lower end of the ileum about 3 or 4 feet long was examined. If the worm was found, the entire intestine was obtained and examined.

At different times during the year 310 intestines were examined in this manner. Of this number only one lightly infested intestine was found. This, with the two reported in 1927, makes three infestations in a total of 478 intestines examined both systematically and as above-mentioned by the personnel of this station.

In the same districts from which many of these examined pigs were obtained the percentage of hookworm infestation in man is high, sometimes reaching 90 per cent. The same correlation exists in regard to ascarids. In Porto Rico the ascarids of swine are scarce, whereas they are common in man.

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